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SASKATCHEWAN RESEARCH COUNCIL

26th Annual Report
1972

THE RESEARCH COUNCIL ACT, 1965, Clause 21, in part, directs that:

1. The Council shall on or before the last day of February in each year submit to the Lieutenant Governor in Council a report of its proceedings and transactions during the next preceding calendar year, which report shall contain such particulars as the Lieutenant Governor in Council may prescribe.

2. Every report shall forthwith be laid before the Legislative Assembly if then in session or, if it is not in session, within fifteen days after the opening of the next session.

Regina, February 5, 1973

TO THE HONOURABLE S. WOROBETZ

Lieutenant Governor of the Province of Saskatchewan

MAY IT PLEASE YOUR HONOUR:

The undersigned presents herewith, for your consideration, the report of the Saskatchewan Research Council for the year ended December 31, 1972.

Respectfully submitted,

Gordon MacMurchy, Chairman
Saskatchewan Research Council

PLEASE ADDRESS CORRESPONDENCE TO:

Saskatchewan Research Council
30 Campus Drive
Saskatoon, Saskatchewan
S7N 0X1

104-03590/

1972 IN REVIEW

The Saskatchewan Research Council, established by Act of the Legislature in 1947, celebrated its 25th Anniversary in 1972. An Open House on May 11, 12, 13, and 15, presented major activities of the Council's program by means of a 30 minute illustrated commentary and a series of laboratory displays. Invitations to Members of the Legislature, members of the public service and Saskatchewan industry, interested public, the university community, high school and technical institute students resulted in an attendance of some 1200. For the occasion the Director, Dr. T. E. Warren, wrote "A Brief History of the Saskatchewan Research Council" and J. L. Bergsteinsson and W. E. Taylor produced a brochure entitled the "First 25 Years".

On May 31, 1972, Dr. T. E. Warren retired as Director and was succeeded by Dr. T. P. Pepper. Tom Warren, the first Director of Research had served since 1956. He guided the Council through its evolution from a granting agency to an independent research establishment with its own laboratories and scientific staff. To honour the retiring Director, and as part of the 25th Anniversary celebration, a banquet was held on May 11 in the Saskatoon Centennial Auditorium at which 350 staff and invited guests attended. The Honourable G. MacMurchy, Chairman of the Saskatchewan Research Council, presided at the banquet. Speakers included Mr. Harold Horner, Vice-Chairman of the Council, who spoke on the work of the Council, and Dr. K. J. McCallum who added personal comments to a tribute to Tom Warren, prepared by the President of the University, Dr. J. W. T. Spinks who unfortunately was ill.

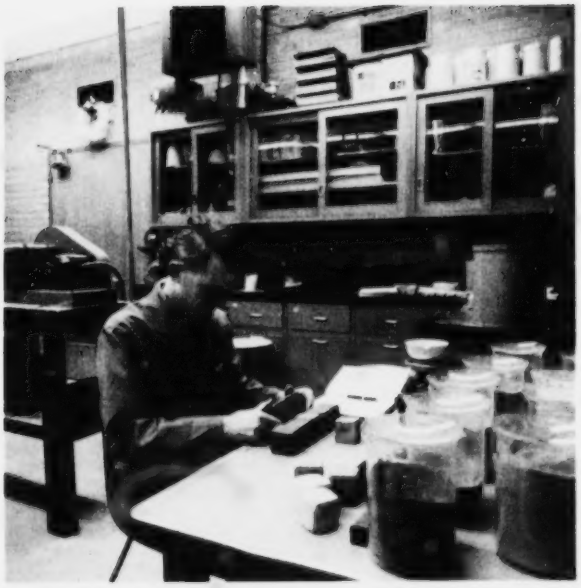
Some aspects of the 1972 program of the Council are illustrated in the accompanying photographs. With the laboratories now equipped to provide a number of services and with areas of technical expertise established, increased emphasis has been directed towards serving provincial government departments and Saskatchewan industry. During the year, management met with senior staff of 13 provincial government departments and agencies in Regina in order to learn in what ways the Research Council's laboratory and staff could become more useful to the provincial government. Remunerative work, contracts, research agreements, etc. with government and Saskatchewan industry continued to increase during 1972. In addition, a special effort was made to assist Saskatchewan industry to take fuller advantage of the various federal government research and development assistance programs.

During 1972 the directors of the seven provincial research councils and foundations, including S.R.C., through the Non-profit Industrial Research Association of Canada (NIRAC) continued to pursue its main mission of seeking a more effective role in advancing Canadian technology and industry. An initial meeting with representatives of the Ministry of State for Science and Technology (MOSST) was held on October 25 in Ottawa. Representatives of other federal government departments and agencies were also in attendance. Further meetings are planned.

T. E. Warren, B.A.; B.Sc.; M.Sc.; Sc.D.
Director
1956 - 1972

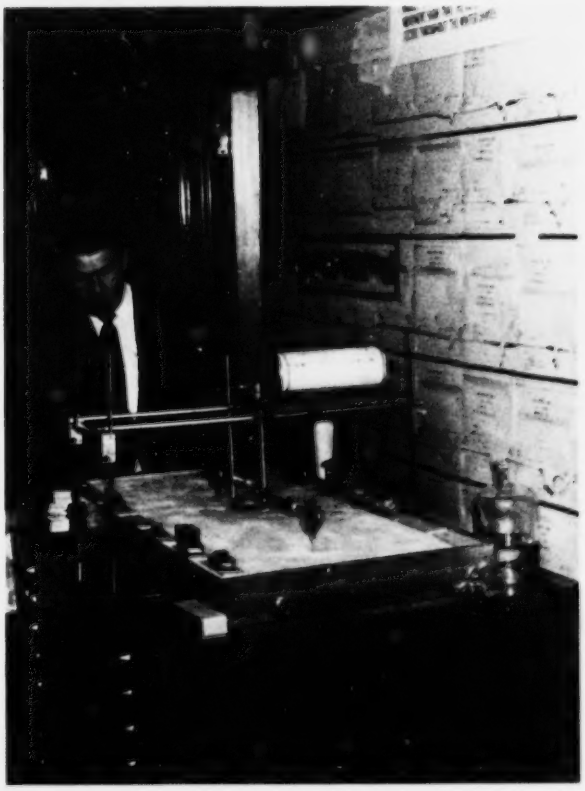
LEGISLATIVE LIBRARY OF ONTARIO
TORONTO
MAR 1 9 1973
RECEIVED

T. P. Pepper, B.A.; M.A.; Ph.D.
Director
1972 -

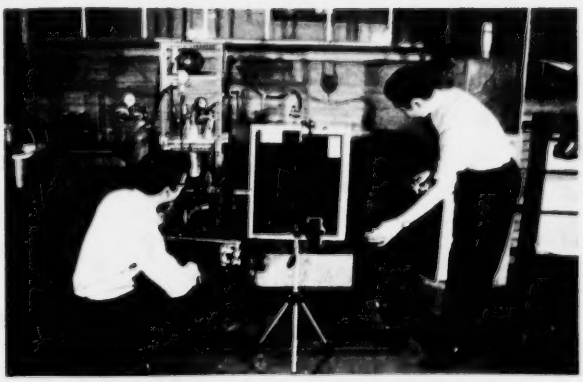


CANADA'S ONLY CERAMICS RESEARCH FACILITY **available for contractual work on heavy clay products is maintained by the Saskatchewan Research Council. Ceramicist John Hudson is shown color matching prototype bricks produced from Saskatchewan clays for an industrial client.**

CANADA WINTER GAMES 1971 **was faced with a critical parking problem. The solution involved parking thousands of cars on the ice at Blackstrap Reservoir. Bill Meneley, S.R.C. hydrologist, played a key role in solving this ice mechanics problem. He is shown here with a model of the Blackstrap ice sheet on display at Open House.**

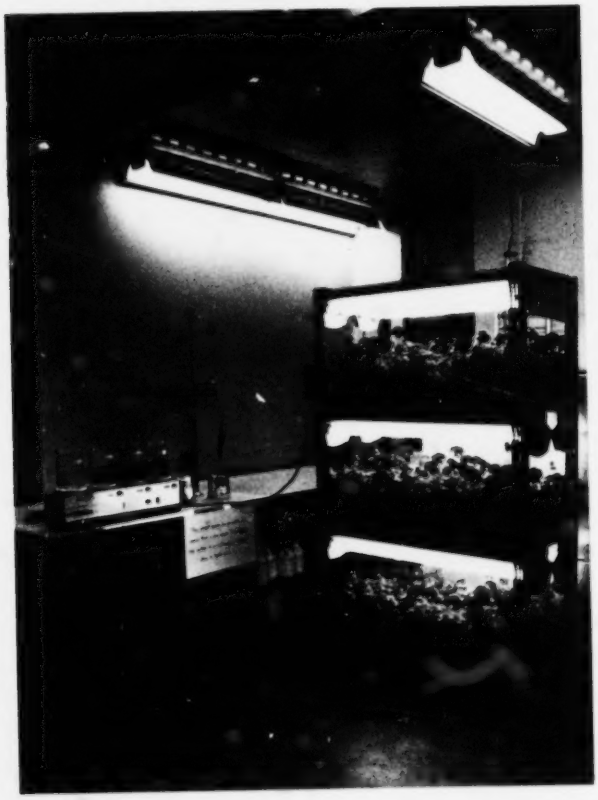


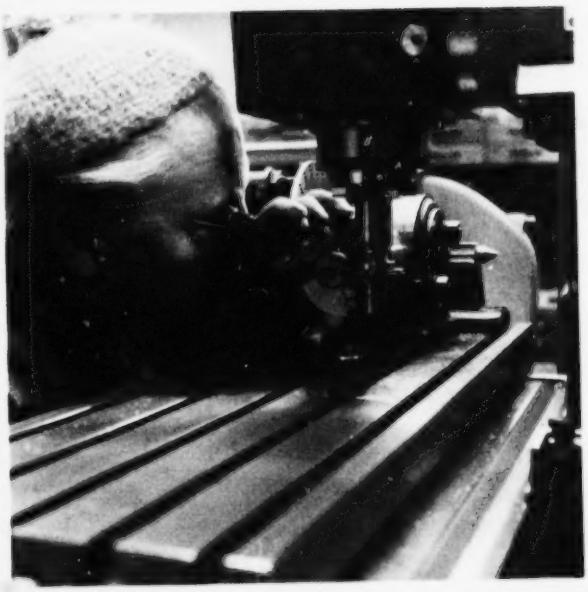
TECHNICAL INFORMATION **is furnished on a free and confidential basis to Saskatchewan industry under a National Research Council supported program. Here Gordon Pierce (right), S.R.C. information specialist, advises a motor home manufacturer on new standards for seat belt attachment.**



HERBICIDE SPRAY TECHNIQUES, **including spray nozzle design, are investigated by S.R.C. researchers. Here physicists John Maybank (left) and Ken Yoshida (right) inspect a nozzle test setup. This program receives financial support from Canada Agriculture.**

GERANIUM GROWTH can be controlled by the addition of growth regulating substances derived from leonardite, an oxidized form of lignite. Tests on the geraniums shown here form a part of the wide-ranging investigations conducted by S.R.C. on Saskatchewan's lignite coal resources.





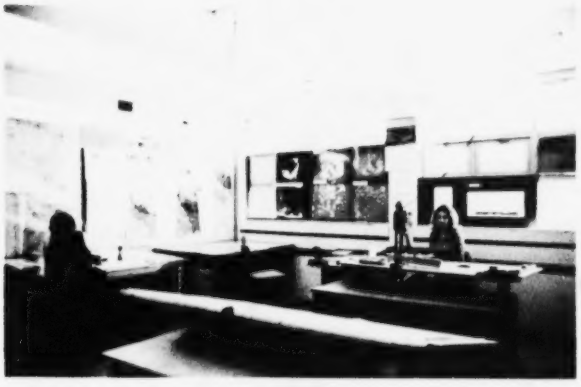
PRECISION INSTRUMENTS used in the S.R.C. field and laboratory programs can, in most cases, be calibrated, maintained and serviced in Council facilities. Precision machine shop supervisor Rudy Heinze inspects a gear constructed for an S.R.C.—designed instrument.

INDUSTRIAL ENGINEERING is a key component of S.R.C.'s program of assistance to Saskatchewan industry. Alan Scharf, S.R.C. industrial engineer (left), is shown discussing long-term operating plans with the president of a Saskatchewan manufacturing concern.

LARGE-SCALE WATER IMPROVEMENT is undergoing further testing at an S.R.C. installation near Bruno. Ice made from local, brackish water during the winter will provide a source of fresh water during the initial spring melt period. Council shop staff are shown here spreading a liner on the product water dugout.

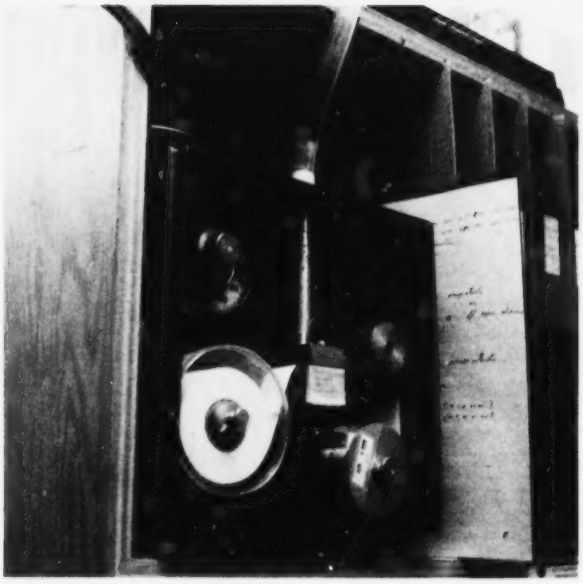
LIBRARY FACILITIES at the Council are an important tool for staff and industry. The library contains more than 5000 books, 400 different periodicals, 10,000 reports and pamphlets, and 25 abstracting and indexing services. Librarian Tish Murphy is shown locating a journal.

MINNOWS ARE COLLECTED at Wollaston Lake to establish conditions among the lake's fish population prior to a major uranium mine becoming operational. Biological surveys are a new component of the Council's environmental monitoring capability.



CARTOGRAPHIC DRAFTING is a highly developed skill at the Council. Precision, clarity and speed are required to present the wealth of geological information in S.R.C. files. Map drafting facilities were displayed at Open House by Clarence Elias (left) and Caroline Bain (right).

COMPREHENSIVE MONITORING of weather information is carried out at the Council's climatological reference station. The station also plays an important role in the calibration and development of special instruments to meet severe Prairie environmental conditions.



AIR POLLUTION has been monitored by the Council at Saskatoon for the past five years. This instrument automatically collects air samples and records the aerosol content on a round-the-clock basis.

SPECIAL INSTRUMENTS are needed to meet special Saskatchewan conditions. Dave Eyre (centre) checks measurements as Bert Pope (left) and Ken Owens (right) finish parts for a dye tracer device for evaluating spring runoff on small streams.

GEOCHEMISTRY of Saskatchewan ores is explained to a group of highschool students during Open House. Geologist Salem Sangemeshwar shows maps of various mineral-bearing formations.

HELPING FARMERS with items such as plans for a do-it-yourself well cleaning dredge has always been a major consideration at S.R.C. Dredge plans formed part of the display at the S.R.C. Open House.

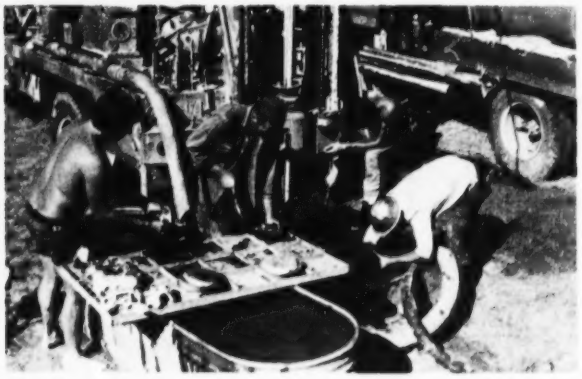
X-RAY METHODS are used to investigate the composition of rock samples gathered in northern Saskatchewan in order to obtain clues to mining potential. Ralph Arnold, chief geologist, is shown adjusting the X-ray spectrometer.

AERIAL PHOTOGRAPHS are an invaluable tool in many types of study. The Council maintains a very extensive collection of Saskatchewan air photos. Chuck Faulkner is shown preparing a display of air photos for Open House.

RADIOCARBON DATING FACILITIES, a joint venture of the Saskatchewan Research Council and the National Museum of Man permit the dating of materials 30,000 years old. Jurgen Wittenberg adjusts the counting electronics as pulses from the 20-ton sample chamber (left foreground) are registered. The Saskatoon lab is one of two in Canada equipped for radiocarbon dating.

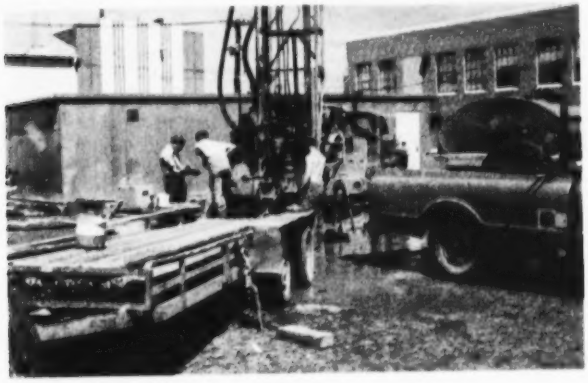
ENGINEERS AND SCIENTISTS FROM SASKATCHEWAN RESEARCH COUNCIL, supported by Department of Highways and University of Saskatchewan professionals, conducted this field trip for the Regina Geotechnical Group and the Saskatchewan Geological Society. Participants study an outcrop of the glacially-deformed Odanah Member near Hazel Cliffe in the Qu'Appelle Valley. The purpose of the trip was to study the geology of the Qu'Appelle Valley and its implications to engineering practice.

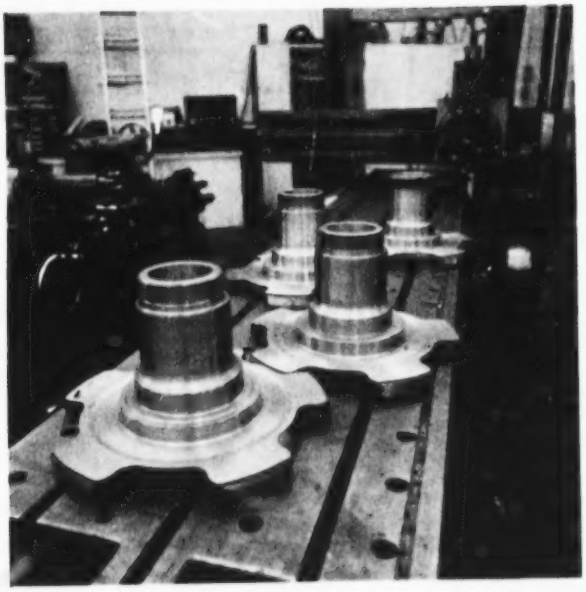
COAL STUDIES involving many aspects of Saskatchewan's multi-billion ton lignite reserves were a major item at the Council last year. A major program of explorational drilling has established the geological framework for further coal investigations. Samples retrieved from drilling fluid, by the contractor, are bagged by S.R.C.'s Ian McPhadden (left) examined in the field and returned to S.R.C. for laboratory studies.



ELECTRONIC INSTRUMENTS, such as soil temperature data logging system shown here, are key components of many S.R.C. programs. The soil temperature monitor, fully automated and computer-compatible, was designed by the S.R.C. electronics laboratory to support a study of groundwater supply. The electronics laboratory also does service work on scientific instruments for non-Council clients on a fee-for-service basis.

S.R.C. - UNIVERSITY CO-OPERATION is exemplified by a study of foundation conditions in the downtown area of Saskatoon, supervised by Professor W. G. Watt, Saskatoon campus civil engineer. The deep hole shown here was drilled on Riverview Collegiate grounds. E. A. Christiansen, S.R.C. geologist (left), studies an electric log of the testhole. The university study was supported by an S.R.C. grant.





A POTASH MINING MACHINE, of special design to meet Canadian conditions, is being developed by a Saskatchewan manufacturer. Council staff was instrumental in preparing an application for federally-sponsored Program for Advanced Industrial Technology (PAIT) grant as well as in providing technical information to support the program. Parts of the prototype machine are shown in the company's plant.

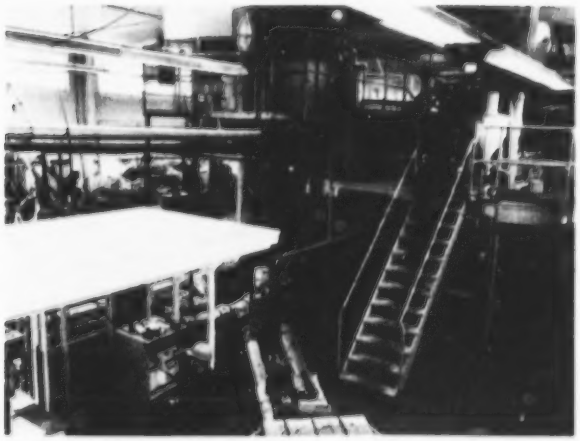
A HIGHLY SKILLED TEAM works in the Council's analytical laboratory, assessing new techniques and processes, providing support for in-house research programs and carrying out analytical work for industry and government on a fee-for-service basis. Staff members shown are Maria Seeback (left foreground), Merv Petrow, Lloyd MacDonald, Judy Towstego (centre; left to right) and Ernie Mueller (right background).

SASKATCHEWAN RESEARCH COUNCIL'S BOARD OF DIRECTORS, which provides overall policy guidance to the staff, meets at various Saskatchewan centres for a first-hand view of local situations. Here (left to right) Board members R. N. H. Haslam and A. B. VanCleave, T. P. Pepper, director of research, and W. H. Horner, vice-chairman of Council, view the scene in a Swift Current plastics plant following a Council meeting.

S.R.C. GRANTS FOR UNIVERSITY RESEARCH in areas of key interest to the Province have led to many valuable discoveries. Dr. Frans Rummens, Regina campus chemist, is shown here with a model of a diallate molecule. Dr. Rummens found that diallate, a herbicide used to control wild oats, consists of two molecular types (isomers) differing only in the position of the chlorine (shown in green) atoms in the molecule. One isomer is more effective in controlling wild oats than the other. Changes in the manufacturing process, leading to increased production of the effective isomer, can reduce pollution hazards and give more efficient wild oats control.

REMOTE SENSING from aircraft or satellites holds great promise in large, sparsely populated areas like Saskatchewan. The techniques require many experts in order to get results and interpret them. False color infrared air photographs, such as Saskatoon campus horticulturist S. H. Nelson has shown here, can separate various crops, and stresses on them such as drought or disease. The blue-green area at the top of the picture is fallow while the purple area in the centre is a potato crop; the bluish area to the right of the potatoes is harvested alfalfa while the dark purple area, (bottom) is green alfalfa. The purplish spots to the sides of the potato field are depressions where moisture is high. This University project was supported by a Council grant. Saskatchewan's remote sensing program is coordinated by an inter-agency committee chaired by Dr. T. P. Pepper, Council director.

COUNCIL CHAIRMAN Hon. Gordon MacMurchy (left foreground) looks on as Merv Petrow of Council staff (right foreground) demonstrates analytical lab facilities during Open House. Brad Gunn, Council's chief chemist, (left background) describes operations to Harold Horner, Council vice-chairman, (right background).



TRANSPORTATION BY PIPELINE is under investigation by the Council. Bulk commodities such as coal, potash and sulphur can be carried considerable distances suspended in a carrier liquid. Studies of pipeline technology are carried on in the special laboratory shown here. Mike Small (seated) monitors pipeline performance while Al Richardson (right) adjusts a valve and Ken Maloff (centre) weighs a sample of slurry. Slurry pipeline research is largely supported by contracts such as those with the C.N. and the Canadian Transport Commission.

MEMBERS OF THE SASKATCHEWAN RESEARCH COUNCIL

The Honourable Gordon MacMurchy, Chairman
W. H. Horner, Vice Chairman
W. K. Setter, Secretary
J. H. Archer
B. W. Currie
J. Roe Foster
R. N. H. Haslam
C. A. L. Hogg
J. B. Mantle
G. C. Mitchell
E. R. Olson
R. H. D. Phillips
H. A. Prefontaine
J. W. T. Spinks
R. V. Tomkins
A. B. VanCleave
C. R. Webster
J. G. Wotherspoon

EXECUTIVE OFFICERS OF THE COUNCIL'S STAFF

Director ..... Dr. T. P. Pepper
Administrative Officer ..... Mr. R. E. Melvin

Division Heads

Chemistry ..... Dr. Brad Gunn
Engineering ..... Dr. W. H. W. Husband
Geology ..... Dr. R. G. Arnold
Industrial Services ..... Mr. I. S. Evans
Physics ..... Dr. J. Maybank

PROCEEDINGS OF THE COUNCIL

Membership of the Council increased from 17 to 18 during 1972 with the addition of Mr. Hubert A. Prefontaine. The Research Council Act allows for a maximum membership of 21. There were no resignations. Dean J. B. Mantle, whose term of office had expired, was re-appointed.

The Council met four times during the year: on February 9 and April 13 in Regina, May 11 in Saskatoon, and September 18 in Swift Current. The meeting on April 13 was called to receive the recommendation of the Committee to Consider Selection of a New Director, consisting of the Honourable G. MacMurchy, Mr. E. R. Olson and Dr. B. W. Currie. Council approved the Committee's recommendation that Dr. T. P. Pepper succeed Dr. T. E. Warren on his retirement on June 1, 1972. The three other regular meetings considered recommendations of the Appointments and Technical Committees. The September 18 meeting in Swift Current included also a tour of Hara Products and a luncheon at which the Council was host to local civic, industrial, and government representatives.

Members of the Technical Committee during 1972 were Dr. B. W. Currie, Chairman, Mr. W. H. Horner, Mr. E. R. Olson, Dr. A. B. VanCleave, Dr. T. E. Warren (to May 31), and Dr. T. P. Pepper (from June 1). The Committee held meetings on January 18, March 27, and August 28 to carry out its regular duties which are to oversee the work program, to recommend grants-in-aid of University research, and to select the applicants who are to receive Province of Saskatchewan Graduate Research Scholarships.

Members of the Appointments Committee were Mr. E. R. Olson, Chairman, Mr. G. C. Mitchell, Dr. J. W. T. Spinks, Dr. T. E. Warren (to May 31), and Dr. T. P. Pepper. Committee meetings were held April 13, May 4, and August 28. The regular duties of the Committee are to make recommendations to the Council on matters relating to the staff, including establishment of positions, appointments and salaries. Three new positions were established and filled as follows by reclassifying staff from temporary status: Mrs. J. Suggitt as Research Council Technician II in the Chemistry Division; Mr. C. Sardinha as Draftsman II in the Geology Division; Mr. H. Martinsen as Research Council Technician II in the Engineering Division. Mr. L. Fertuck, on leave of absence during 1971, resigned from staff. The following staff members were reclassified from temporary status to vacant established permanent positions: Mrs. P. K. Colbourne to Clerk Steno II in the Division of Industrial Services; Mrs. D. L. Shumyla to Steno I in the Administration Division; Mr. E. Mueller to Associate Research Officer in the Chemistry Division; Mr. K. Yoshida to Assistant Research Officer in the Physics Division; Mr. R. Reich to Research Council Technician II in the Physics Division. Dr. J. Maybank succeeded Dr. T. P. Pepper as Head of the Physics Division, June 1, 1972 and was reclassified as Senior Research Officer.

The Forward Planning Committee did not meet during the year.

CONTENTS

Members of the Saskatchewan Research Council 1
Executive Officers of the Council's Staff 1
Proceedings of the Council 2

PROGRAM OF THE COUNCIL'S STAFF

CHEMISTRY DIVISION 7
Potash Industry 7
Lignite 7
Agriculture 8
Environment 9
Service Functions 9
Analytical Services 9
Carbon-14, Tritium Dating 9

ENGINEERING DIVISION 11
Objectives 11
Functions 11
Ceramic Materials 11
Environment Protection 12
Lignite 12
Magnesium Sulphate 12
Potash 12
Solution Mining 12
Rock Mechanics in Potash Mining 12
Sodium Sulphate 12
Transportation 13
Fundamental Studies 13
Contract Studies 14
Air Cushion Vehicles 14
Water 14
Desalination of Water by Natural Freezing 14
Idylwyld Underpass Storm Drainage Study 15
IHD Study of Big Quill Lake 15
Small Drainage Basin Studies 16
Stream Gauging using Fluorescent Dyes 16
Slough and Pothole Studies 17

GEOLOGY DIVISION 19
Groundwater Geology Studies 19
Sinkhole in Eastern Saskatchewan — Howe Lake 19
Stratigraphy of the Qu'Appelle Valley 20
Urban Geology of Saskatoon 20
International Geological Congress 20
Groundwater Information Services 20
National and Provincial Committees 20
Groundwater Hydrology Studies 22
Conquest Project 22
Subsurface Storage of Desalinized Water 22
Regional Observation Well Network 22
Saskatchewan Coal Evaluation Program 23
Coal Permit Evaluation 23
Cartographic Section 23
Precambrian Geology and Geochemistry 24
Geochemical Field Program 24
Laboratory Program 24

INDUSTRIAL SERVICES DIVISION 25
The Technical Information Service 25
Technical Inquiries 25
Industrial Engineering 25
Technological Developments 27
The Technical Assistance Program 27
Assistance in Obtaining Federal Government Grants 27
Science Service Library 27

PHYSICS DIVISION 29
Meteorology 29
Atmospheric Physics 29
Climatological Studies 29
Pesticide Drift Investigation 30
Geophysics 31
Groundwater Geophysics 31
Lignite and Leonardite Logging Study 32
Instrumentation Services 32
Electronics Laboratory 32
Precision Instrument Laboratory 32

THE UNIVERSITY PROGRAM 35

SCHOLARSHIPS 35

GRANTS IN AID 36

Department of Animal Science
1. The Use of Field Peas in Calf Milk Replacer Formulations 36

Department of Chemistry and Chemical Engineering
1. Research in Fluid-Solids Systems 37
2. Hydrogen Reduction of Sodium Sulphate 37
3. Chemical Analysis of Birch Bark (Betula Papyrifera) 37
4. Photochemical Degradation of Pesticides and Herbicides 37

Department of Civil Engineering
1. Study of Foundation Conditions in Downtown Area of Saskatoon 39

Department of Electrical Engineering
1. Helium-4 Mass Spectrometry for Uranium Exploration 40

Department of Geological Sciences
1. Field Studies of Microseismic Energy Emission 41
2. Stratigraphic Studies in Cretaceous Rocks 41
3. Investigation of the Genetic Aspects of the Flin Flon Ore Body 42
4. Sedimentary Strata of the Prairies 42
5. The Proterozoic/Archean Contact in the Vicinity of the Hanson Lake Road, Saskatchewan 42

College of Home Economics
1. Pollution of Soil, Water and Food by Pesticide Residues in Saskatchewan 43

Department of Horticulture Science
1. Irrigation of Studies with Vegetable Crops 44
2. Remote Sensing of Moisture Stress, Weed Competition and Salt Accumulation 44

Division of Natural Sciences and Mathematics — Regina Campus
1. Preparation of Pure Inorganic Salts 46
2. Isolation on Structure Determination of Diallate Herbicide Isomers 46
3. Method for Investigating and Utilizing Lakewater Algae 46

College of Pharmacy
1. Culture of Medicinal Plants 48

Department of Soils Science
1. Evaluation of Soil Contamination in the Vicinity of Potash Refineries 49

Staff of the Saskatchewan Research Council 51

FINANCIAL STATEMENT 53

PROGRAM OF THE COUNCIL'S STAFF

REPORT OF THE CHEMISTRY DIVISION
By Brad Gunn

The main objective of the Chemistry Division has been the development of processes for secondary industry in Saskatchewan. There are certainly economic reasons for assuming that processing of raw material within the Province is desirable. Unfortunately, there has been convincing evidence that even primary industry frequently requires assistance in Saskatchewan. Hence, a review of the Chemistry Division's activities shows that primary industry has accounted for a large proportion of our time and effort. The chemical analytical facilities have been used to a greater extent by primary industry than by secondary industry. With the addition of biologists to our staff the Chemistry Division has become more deeply involved with environmental studies and this again has brought us close to primary industry. For convenience in this report primary and secondary industry will be discussed without particular differentiation under the headings — Potash; Lignite; Agriculture; Environment; and Service Functions.

Potash Industry

The potash industries in Saskatchewan have their own expertise. However, there are always opportunities for improvements in beneficiation. Some of these for the conventional shaft mines may have to do with the flotation circuit, and may pertain to the reagents. However, the frothers, collectors, and slime supressants are quite standard. From time to time any one of these may receive fresh attention in view of a supply problem or because of the availability of a new product which may have appeal, either for economy or for efficiency. Such products have been tested in our facilities from time to time either at the request of the suppliers or at the request of one of the potash producers. At the same time, there is some concern about a more radical change in the benficiation process, and some progress has been achieved in an effort to modify the process. While it is recognized that present operations represent large investments with a poor return and these will remain unaltered unless there are substantial reasons for change, it is also realized that the storing of large quantities of salts and saturated brine in internal drainage basins or in containment areas with dykes, does pose a threat to the environment. The influence on the environment requires evaluation on an individual site basis. For some locations, a beneficiation process which lends itself to major separation below the surface with the wastes used as back fill, would have inherent advantages over mill operations above ground.

Caking of various products is a problem of general concern to all potash producers, whether they are involved in conventional shaft operations or in solution mining. Caking is defined as a firm adhesion between particles. It may be caused by absorption of moisture from the atmosphere or it may be caused by moisture migrating to the surface from within the particles. In either event moisture at the surface of the particles causes solution of the salt and this is followed by fusion of the particles. There are a number of factors which influence the tendency of an hygroscopic material to cake and there are no general procedures for preventing caking. This explains why various clients have brought their caking problems to the Saskatchewan Research Council. Each problem may be unique but a general approach has been developed for coping with a rather wide spectrum of caking problems.

The philosophy of processing raw products before they leave the Province was the basis of an extensive program on potash conversion processes. Potash is mined as potassium chloride and is shipped and consumed as fertilizer largely without chemical change. However on a weight basis, there are many potash chemicals of higher value than potassium chloride. Naturally it was thought desirable that some of these conversion processes should be undertaken in the Province of Saskatchewan. Previous annual reports have enlarged on such processes as the conversion of potassium chloride to potassium sulphate, to potassium nitrate, to potassium phosphate and to potassium carbonate. Most of the conversion procedures have been thoroughly investigated. For most there are at least two alternate methods which are very well understood. All have been performed on a bench scale. The potassium sulphate process has been carried one stage further to a semi-pilot plant operation. All processes listed above could be taken to the pilot plant stage if a client were interested in supporting this phase of development. Lack of industrial financial support has led to the discontinuation of these studies. The work would be reactivated if the industrial climate were to change or if the literature indicated that an innovative step would improve the economics. Actually, even at this time, the economics appear to be attractive enough to warrant an investor's support.

Lignite

An assessment program to determine the quantity and quality of lignite in Saskatchewan has involved most divisions of the Council. The quality aspect has been the particular responsibility of the Chemistry Division. The analytical data consisting of ultimate and proximate analyses from cores obtained in 1971, were completed early this year and the results are now available. Naturally simple procedures for estimating the B.T.U. values and the ash content of lignite are of particular interest to a supplier of coal when the consumer is a thermal power plant taking delivery directly from the mine. So far, it appears that there are a number of correlations

among lignite properties but as yet there are no simple methods other than chemical analysis or density determinations to serve as quality indicators.

While in general the main thrust on lignite studies has to do with energy potential, the studies by the Chemistry Division have pertained mainly to non-energy uses of lignite and to the use of products associated with lignite. Leonardite belongs to the latter category. It is usually assumed to be an oxidized form of lignite. It contains humates, generally in the form of calcium salts. These can be dissolved in dilute sodium hydroxide solutions. In fact the solubility of coal-like material in sodium hydroxide has become a criterion for the presence of humates. An assessment of the amount of leonardite in the lignite deposits is useful for two reasons. (1) The poor burning characteristics and the low calorific values of leonardite render it unacceptable as an energy source and on this account, areas of leonardite should be determined so as to avoid losses when mining lignite. (2) Leonardite, itself, is interesting because it possesses some unique chemical properties and physical capabilities which indicate that its development may be practical as a separate resource. Before embarking on elaborate laboratory studies or extensive programs to establish the merit of leonardite and the extracts which can be obtained from leonardite, it was imperative that the relative magnitude of the leonardite resources be determined. It was on the basis of these considerations that a contract was sought and obtained from the Mines Branch, Department of Energy, Mines and Resources, Ottawa. The program was to consist of (1) a limited amount of drilling in both lignite and leonardite, (2) a qualitative assessment of the former and (3) a qualitative and quantitative assessment of the latter. The study was not extensive but it produced sufficient evidence to confirm the presence of large quantities of leonardite.

Cores Collected from Coal Evaluation Study

The availability of leonardite encouraged further studies on the use of leonardite or leonardite-derived humates for plant growth studies. There are a number of ways in which humates improve plant growth. First, it is recognized that humates impart certain desirable characteristics to soils and that the growth and development of plants on soils of high humate content are usually superior to those on less humate-rich soils. They appear to improve the physical characteristics of the soils as well as its moisture retaining properties. There is also evidence that they serve as ion exchange media and hence improve the utilization of soil nutrients.

Interesting results were obtained from experiments on rooting geranium cuttings. Cuttings rooted in humic media of concentrations 0.005 to 1.0% responded 5 days of 30% more quickly than those rooted in tap water controls. Even more spectacular was the tremendously rapid proliferation of roots and rootlets in the humic media. There are at least three conclusions from the present growth studies: humates would be helpful (1) in greenhouse operation, (2) in the production of specialty crops, and (3) with selective mining, could be used to initiate the recovery of plant life on spoil piles in the wake of lignite strip mining.

Agriculture

Since there are already many competent federal and provincial agencies primarily involved in agricultural research, the Saskatchewan Research Council confines itself to regionally related studies where existing staff and facilities can be employed on specialized aspects of this vital sector of provincial activities. One of our particular concerns has been the assessment of high protein crops which are adaptable to semi-arid regions in Saskatchewan. It is recognized that a diversified farm economy is dependent on a reliable source of high quality fodder. The stock raising aspect of agriculture in Saskatchewan would be greatly stabilized if drought resistant crops were developed. The statistics on cattle production in Saskatchewan illustrate the devastating consequences of dry years, and hence justify the emphasis on obtaining reliable and adequate fodder supplies at times of adverse climatic conditions. High protein fodder is particularly desirable since it reduces the need for protein supplementation. For human consumption, high protein food sources are in even greater demand. Kochia and quinua appear to meet many of the provincial requirements. However, they suffer from the handicap of containing an undesirable component — saponin. While saponin can be removed by washing, larger scale testing or even selective plant breeding may be required before kochia or quinua can expect wide acceptance as a major crop in Saskatchewan.

Leather studies barely qualify as pertaining to agriculture on the basis that the studies presently undertaken at the Council have been conducted mostly on hides from undomesticated animals. The Saskatchewan Research Council leather studies were initiated as a result of discussions with the Federation of Saskatchewan Indians. The concern over Indian tanned leather arose from increased demand and dwindling supplies of native leather and the garments and mocassins made from them by the native peoples. Indian leathers have become recognized for unique characteristics, notably softness, easy needle penetration and a smokey odor. The logical explanation for the dwindling leather supplies is the inordinately large amount of labor required for producing Indian leather. The task at the Council was to assist the native people in producing the equivalent to Indian smoke-tanned leather by methods which would

reduce the time and labor of tanning. An important aspect of the project was the participation of two ladies from the Northern Co-operative, La Ronge. These ladies were experts in the tanning of Indian leather and they worked diligently at the Council for two months on innovative techniques and procedures with a view to reducing the laboriousness of their accepted methods. Dehairing of moose, deer and caribou skins by the conventional commercial lime-sulphide method was compared with unhairing by enzymatic procedures. Of these, the former was the more effective but suffered from environmental considerations. Either is much easier to perform than the traditional Indian scraping procedures. Tanning to meet the requirements of softness and needle penetration of traditional Indian smoke tanned leathers, was attempted by using various chemical treatments. From the results there is confidence that leather comparable to Indian smoke tanned leather can be produced at a fraction of the labor required by the traditional procedures, but the use of appropriate machinery and suitable modifications of procedures is required.

The methods successfully applied to the hides of wild animals are now being applied to the hides from cattle. Procedures in leather making such as unhairing, dehydrating, tanning, and lubricating are being investigated. Methods of improving the water resistance of leathers are also being studied. In general the procedures used with hides from wild animals are equally applicable to hides from cattle although some difficulties arise from the greater thickness and the greater fat content of cattle hides.

Environment

The program of the Chemistry Division over the past few years has kept pace with growing public concern for preserving our environment. The first involvement occurred when we obtained analytical tools capable of detecting low concentrations of contaminants. At this juncture we were besieged with requests for heavy metal analysis on samples from our streams and lakes, and from commercial commodities hitherto considered pure, or at least uncontaminated. Similarly, analyses for chlorinated compounds or residues of a harmful nature from herbicides were requested by those concerned with other aspects of the environment. Tighter regulations with regard to domestic and industrial sewage led to studies on sewage treatment. At the same time, it has become necessary to monitor certain contaminants in the river system to ensure that deterioration is not continuing to take place. A year ago we had the opportunity of becoming further involved in studying the environment when we accepted a contract from Gulf Minerals Ltd. to do a base line study on Wollaston Lake. Such a study was deemed necessary in order to document information which would establish the quality of the environment before the operation of a uranium mine and mill. The concern and co-operation of our client is such that no deterioration of the environment is anticipated. The company is prepared to make sure that all the precautions necessary to protect the environment will be carried out. For the base line study on Wollaston Lake Dr. W. W. Sawchyn, a qualified limnologist biologist, and Mr. E. Kardash, a biology assistant were added to our staff. Additional field personnel were recruited for the field program.

SERVICE FUNCTIONS

Analytical Services

The Chemistry Division continues to provide chemical analytical services to the Council and to outside agencies. Analytical services are provided for clients at approximately service laboratory costs. Usually the analytical results can be provided quickly; even better service can be assured if a few days lead time are provided. Consulting services on analytical methods are available on request.

Carbon-14, Tritium Dating

The carbon-dating facilities have been expanded from a single to a four channel counting system through the co-operation of the National Museum of Man. The facility is now operating as a joint venture of the Museum of Man and the Saskatchewan Research Council. This contractual arrangement assures a long term work-load and improves the economics of the operation. It will be possible to achieve turn-around times of a month for normal analytical requirements after the present back log of samples has been processed.

Tritium is being used to identify sources and magnitude of water supplies (a) in surface reservoirs and (b) in flowing streams. The Goodspirit Lake records for three years are being analysed for water balance. The main effects on water level and on tritium content occur with the spring run-off. The lack of precision in the tritium measurements precludes interpretation of the effects of precipitation and lake mixing.

Reports and Publications

Kochia Seed as a Component of the Diet of Turkey Poults. Coxworth, E. M., Salmon, R., Can. J. Animal Sci., In Press 1972.

Interim Report on Lignite-Leonardite Study. O'Donnell, R. W.

Micro-Determination of Triterpen Sapogenin Content of Kochia Scoparia Seed Using Gas Liquid Chromatography. Kernan, J. A., Coxworth, E. M., and Fleming, Sharon. Submitted for Publication.

The Auxin-Like Effects of Humic Preparations from Leonardite. O'Donnell, R. W., Soil Science. Accepted for publication.

A Gas Chromatographic Method for the Determination of Sapogenin and Saponin Content and Sapogenin Composition of Quinua and Kochia Seeds. Coxworth, E. M., and Fleming, Sharon. Submitted to the Journal of Agricultural and Food Chemistry.

Indian Leather Project Report. Coxworth, E. M. (Confidential)

REPORT OF THE ENGINEERING DIVISION

by W. H. W. Husband

OBJECTIVES

The Engineering Division conducts a program, within the overall research program of the Council, with the following objectives:

1. to provide engineers and scientists fully familiar with the technical details of each existing industry in Saskatchewan and who are available to advise government, industry, labor, and private individuals;
2. to solve problems of existing industries;
3. to develop new technology for utilizing the natural resources in the Province;
4. to protect the environment of Saskatchewan.

Staff and projects must be both flexible and versatile to cope with constantly changing economic and social conditions.

FUNCTIONS

The Engineering Division undertakes technical and economic feasibility studies, pilot plant investigations and basic engineering research. Technical assistance is provided to organizations and individuals upon request. Equipment design, construction, and maintenance services are provided to the other divisions of the Council.

Technical studies involve the conception and initial investigation of new uses and methods of more efficient recovery of Saskatchewan raw materials and other resources. Economic studies are made to evaluate the commercial feasibility of the concepts and the results of the technical studies. Pilot plants and other types of large scale operations are used to obtain accurate and comprehensive information for the processes, designs and the techniques which have been developed in the laboratories. Basic engineering research provides fundamental data for the development or improvement of specific parts of a process or equipment. Special technical services are available to organizations and individuals throughout Saskatchewan upon request. These services are provided by the technical personnel employed in the Division's regular research program, and care is taken to avoid competition with consultants or engineering firms within the Province. A diversified workshop is maintained to provide construction and maintenance services for all divisions within the Council.

CERAMIC MATERIALS

A well equipped ceramics laboratory is maintained to provide services to anyone involved in the manufacture of brick, tile, sewer pipe, cement and other ceramic materials. The amount of contract research carried out this year in the ceramic laboratory remained high. Field and laboratory studies were continued for the Estevan Brick Division of Peben Company Ltd. A large project is being carried out for Indusmin Ltd. One clay and several kaolinized sand samples were examined for the Department of Mineral Resources. Consequently, progress upon in-house projects was slow.

Studies were continued on the development of granular, porous products suitable as cat litter and garage floor cleaners. Consumption of such materials in Canada has been estimated as several million pounds per year, all supplied by imports from the United States. As the products appear to be calcined clay, and as Saskatchewan has large reserves of various types of clays, an attempt to make a substitute from local materials is appropriate. The product needs to have 55-60% by volume of fine, uniform, and interconnected porosity, and yet still have considerable mechanical strength.

Hard shales from various locations in southern Saskatchewan were fired, without processing, to 600 C to see whether any developed natural porosity on firing, as do some foreign clays used for cat litter. They did not. Fired porosities were about 35%.

A more fruitful investigation involved the study of the reaction between NaOH + kaolinite-based Saskatchewan clays. Porous materials were obtained upon reacting Eastend area stoneware clays or Willowbunch clays with 50-100 pounds per ton of NaOH at 90 C for one week in closed jars, and drying and firing to 900 -1,000 C. Materials fired to 900 C had 50-55% porosity, but were too weak; those fired to 1,000 C were stronger, but the porosity was low at 45-50%. When firing to a temperature that gave 50% porosity, the products had about two-thirds the strength of commercial cat litters. The most recent experimental work consisted of adding small amounts of lime to the reaction mixture. Porosities of 60% or more were obtained with low firing temperatures. However, when fired to temperatures high enough to produce adequate strength, the porosities were down in the 50% range. Mixing might have been insufficient. The study will be resumed when time becomes available and it is planned to test the use of Boundary Dam flyash as a source of lime.

The reaction mechanism was studied by using X-ray diffraction. The action of NaOH upon Saskatchewan kaolin behaves as a classic case of successive reactions. Kaolinite reacts with the NaOH to form zeolite (species P) which reacts with additional NaOH to give hydroxysodalite.

It is unusual to find kaolinites reactive enough to give zeolites by the reaction of uncalcined clay with NaOH. In this case three grams of NaOH to 10 grams of kaolinite are about the stoichiometric amounts required for hydroxysodalite formation. If there is insufficient NaOH for the kaolinite, the reaction stops at zeolite P; if there is an excess of NaOH, hydroxysodalite is formed, the larger the excess of NaOH, the faster the reaction occurs. With 100 pounds of NaOH per ton of Eastend stoneware

clay (35-45% kaolinite), only zeolite P is formed, and subsequent dehydration results in the observed porosity of the product.

The drying properties of hard-to-dry clays were investigated further. Almost all Saskatchewan red-firing clays, of both glacial and pre-glacial derivation contain sufficient montmorillonite clay minerals to make them difficult or impossible to dry without cracking. This is unfortunate because red-firing clays are in demand for brick manufacture. As indicated in the 1969 Annual Report, long chain amines in the 6 to 12 carbon atom range have been found which, when added in their salt form to these difficult-to-dry clays, make the clays water repellent enough to be dried safely. However, these amines are far too expensive for this use. Recently it has been found that urea, formaldehyde and the ammonium salt of any strong acid react when mixed with these clays to form a cation of unknown structure which occupies the exchange portions of the clay and confers to it water repellency. Minimum quantities required appear to be about 25 millimoles of urea, 25 millimoles of formaldehyde, and 17 milliequivalents of ammonium salt for 300 grams of a clay whose cation exchange capacity is 13.5 milliequivalents per 100 grams. This is about half coverage of the cation exchange sites on the clay. Cost of reagents is in the order of 6-10c per pound. A problem to be solved concerns the metallic cations displaced on the exchange sites. So far, a way has not been found to prevent the formation of this deposit under the slightly acid conditions needed to keep the organic cations stable.

ENVIRONMENT PROTECTION

Meetings were held during the year with various government departments and agencies to discuss techniques and programs related to air, water and soil pollution. The use of lignite flyash for sewage effluent treatment and for algae control is under preliminary investigation. Several methods of disposing brine from water desalination processes were being examined on a large scale in connection with the full scale study on desalination of water by natural freezing.

LIGNITE

The main research program was deferred during the year because of lack of staff and funds. A watch is being kept on the technical literature for coal gasification methods and alternate energy sources. Lignite from the Estevan area has been included as one of the materials being tested in the program on hydraulic transport of solids under contract with the Canadian Transport Commission.

MAGNESIUM SULPHATE

The general research program was deferred during the year because of lack of staff and funds.

POTASH

Solution Mining

Much of the potash ore in Saskatchewan is at depths inaccessible to conventional mining methods, but the ore is within the range of the solution mining technique. Potash ore dissolution rates have been studied in the laboratory and a cost analysis has been made. A study of the mass transfer process involved in solution mining has been in progress since 1966. Mathematical models of the process have been developed and experimental work is being conducted to test the validity of the models for design purposes.

Rock Mechanics in Potash Mining

In mining deeply-buried potash deposits, particular problems arise because of the low strengths of salt and potash rocks and because of their solubility in water. The potash mines in Saskatchewan are extracting potash ore at depths of 3,100 to 3,500 feet and below water-bearing sediments. Seepage of water into a mine must be prevented because the water would dissolve salt or potash, continuously enlarge its passageways, and inevitably would result in flooding of the mine. Many salt and potash mines in other countries have been lost in this manner.

The companies operating potash mines in Saskatchewan are concerned about designing the underground excavations and the pillars left in mined-out areas for permanent overburden support. These pillars must be designed so that deformations which might cause water seepage from formations above the mines are prevented. Because of the low strengths of salt and potash rocks, the pillars left for overburden support tend to deform continuously into underground openings by what is termed "creep". This is a slow but continuous deformation. It is possible and necessary to control the creep sufficiently to prevent excess deformation.

The objective of the rock mechanics program is to determine design parameters which may be applied to develop safe mines. The creep into the mine openings, and the deformation of the overlying formations must be controlled to insure safe mines for the long term recovery of potash.

On April 1, 1971, the Council, the Saskatchewan Department of Mineral Resources, and four potash companies began a research program to evaluate underground measurements carried out in their mines to determine adequate design parameters for the development of safe mines. On April 1, 1972, the program was modified slightly when one of the four potash companies withdrew from the study. The program has continued with the three companies sharing information from each mine.

SODIUM SULPHATE

Personnel of the Division maintain contact with the technical people in the 7 sodium sulphate plants in the Province. Each plant is visited to maintain liaison between the industry and council staff so that technical assistance can be provided to the industry when required.

A number of alkali lakes in the Province are being sampled at regular intervals. Analysis of these brine

samples provide data on the mineral content of the lakes and show the effects of seasonal weather changes.

TRANSPORTATION

Fundamental Studies

Saskatchewan's resources such as grain, wood pulp, potash, oil, gas, coal and metallic ores must be transported over long distances to world markets. The Division, in co-operation with the Department of Chemistry and Chemical Engineering of the University of Saskatchewan, is studying ways of reducing transportation costs so that Saskatchewan can compete more effectively on world markets.

The commercial pipeline transportation of such materials as coal, limestone, phosphate rock and metallic ores in slurry form has been shown to be technically and economically feasible even over relatively short distances of 5 to 100 miles. In Canada where many raw materials are ideally suited for solids pipelining, one would expect application of solids pipelining to develop quickly. However, only a few research groups throughout the world have undertaken studies into solids pipelining and the resulting information has become the property of a few consulting firms. Consequently, data and methods have not been freely available for rapid preliminary evaluation of solids pipelining applications by the many companies which might use such a method of transportation.

The Saskatchewan Research Council has been conducting studies of the flow of solid-liquid suspensions since 1960. In general, theoretical studies have been undertaken by graduate students under the direction of Professor C. A. Shook of the Department of Chemistry and Chemical Engineering, while the construction and operation of experimental pipelines has been the responsibility of engineers and technicians of the Saskatchewan Research Council. Initial equipment consisted of an experimental pipeline loop with a one inch by four inch rectangular test section. As various phases of the development program progressed, additional equipment was installed and eventually pipeline loops varying from 2 to 14 inches in diameter were operated. Materials such as potash, copper concentrates, Athabasca tar-sands, limestones, iron-ore concentrates and many different types of coals have been pumped through these pipeline loops.

In September of 1970 the Transportation Development Agency (TDA) through the research branch of the Canadian Transport Commission (CTC) selected the Saskatchewan Research Council to develop accurate engineering design data from large-scale slurry pipeline facilities and to continue basic studies in the interests of the advancement of solids pipelining in general. The program now is in its third year and should be completed in 1973.

During the first year, an intensive maintenance and reconstruction program was undertaken to permit experimental studies with such commodities as iron-ore concentrates, coal, limestone and sulphur. At the same time, small scale preliminary work with material such as iron-ore concentrates, limestone, sulphur and sand were started immediately. For the purpose of correlating experimental results of the various materials, sand is uniquely suited as a standard reference material because it is inert and therefore can be suspended in any desired liquid. It is inexpensive and its size distribution can be specified; furthermore, it can be subjected to many hours of hydraulic transport without showing appreciable amounts of attrition. Consequently, the bulk of the experimental work completed during the first year of operation was with mixtures of sand in three different liquids. Water was used as a standard liquid. Calcium chloride brines with specific gravities of 1.15, 1.25 and 1.35 were used to characterize liquid carriers possessing different densities. Ethylene glycol has been used to characterize the carriers with varying viscosities. The results of the preliminary work was described in Progress Report No. 3 to the TDA.

During the second year of the program, the small scale experimental work was continued and large scale work was begun with iron-ore concentrates and various types of coals. At this stage of the program, new problems were identified which resulted in considerable research activities to improve, confirm and increase understanding of the test results. In addition, several improvements were made to the performance of instrumentation and equipment.

An important improvement was the development of pressure measuring equipment which can be used in the presence of slurries of any solids concentration and with any yield stress. Also, a freeze protection system has been developed to provide year-round pilot plant operation and to improve output of the facilities. The materials handling capacity of the facilities has been increased to deal efficiently with the loading and disposal of 30 to 40 tons of material in bulk, in drums or in slurry form.

A prediction of the pressure drop of certain slurries can sometimes be made more easily if the slurry viscosity is known. Therefore, efforts were continued to develop reliable viscometry methods for different types of slurries. Materials such as iron-ore concentrates, coals, and limestone are being used as reference materials in this development. Slurry viscosities can generally be altered significantly by the addition of heavy polymers. The influence of some of these additives on the pressure drop of coal limestone slurries also is under study.

In mountainous terrain it is necessary to establish maximum permissible pipeline slopes to ensure that slumping or sliding does not occur on the bottom of the pipe wall when the pipeline is shut down. Maximum permissible slopes were established for granular materials. When a slurry contains significant amounts of fines, such a shutdown may result in the formation of a bed of coarse material on the bottom of the pipe and overlain by a mixture of liquid and small particles. As most of these particles continue to move slowly toward the bed, there will be a density gradient in this fluid layer and this

will result in two density currents in a sloping pipe. The dense layer in the lower part of the mixture will flow downward along the bed of coarse particles and the less dense layer near the top of the pipe will flow upward along the top of the pipe. These currents will eventually result in the formation of plugs at the low points along the pipeline and could result in ultimate blockage of the pipeline. Test facilities have been constructed to produce such density currents, to permit observation of these density currents, and to permit a study of the effects of pipeline slope and pipeline length on the density of the plug and on the pressure required to refluidize the plug. Considerable experience has been accumulated using limestone and iron-ore concentrates.

The terminal settling velocities of individual solids are required to characterize the solids in solid-liquid mixture flows such as density currents and slurry pipeline flows in general. These have been determined for coals, limestone, sands, iron-ore concentrates and potash.

Present solids pipelining facilities at Saskatoon consist of two-, four-, six-, eight-, ten- and twelve-inch diameter pipeline test loops. Both the two-inch and the six-inch loops can be inclined to any desired slope up to 30%. All loops are fully instrumented for the measurement of variables such as discharge rate, solids concentration, temperature, solids size distribution and pressure drop. Most of the test loops also are instrumented with gamma ray density apparatus for the recording of the vertical density profiles inside the pipe. Concentric heat exchangers permit operating temperatues to be controlled at all times at any desired temperatue from 40° to 150° F. An additional 2-inch diameter pipeline test loop is avilable to permit studies with volatile and explosive mixtures such as solid materials in crude oil. Also, this latter test loop has the feature of being able to provide hydraulic data for a very small amount of solid material.

The development of a particle and fluid velocity probe has been undertaken to permit the study of mixture flow processes on a near microscopic scale. Preliminary tests with a prototype particle velocity probe are very encouraging. The probe has been modified to include a fluid velocity measuring device, operating on a pulsed heat input principle. Three of the double purpose probes have been constructed and are about to be calibrated. The particle velocity system has been installed as a flush mounted device in the walls of 8-inch and 12-inch pipe sections where it is hoped that these devices will throw some light on the bed regime in slurry flow.

A number of complimentary research projects are supported from the program funds. The first of these is a corrosion-erosion study in steel pipelines carrying such water based slurries as iron-ore concentrates, metallurgical coal, lignite, potash and sand. This project is in progress at the Regina Campus of the University of Saskatchewan under the direction of Professors E. B. Tinker and J. Postlethwaite. Corrosion rates have been determined for the slurries and efforts are now underway to develop preventative techniques. The second study is concerned with the causes of the critical velocity phenomenon, the velocity at which solids drop out of the slurry, and it is attempting to find a theoretical explanation of the empirical design equations so that these equations can be used in a predictive manner for design purposes. A third project is a study of the response of pipelines to slurry flow changes such as are encountered during pipeline start-up or shut-down. A fourth study is designed to provide a model of the fluid flow in a helically ribbed pipe so as to provide a basis for future slurry studies in such pipes. Helically ribbed pipes have been shown to have advantages over smooth pipes in the transportation of some solid liquid mixtures. The reasons for this behaviour must be understood before helically ribbed pipelines can be designed properly for slurry transport.

Contract Studies

The Division continued to undertake full scale studies of the hydraulic transport of particular materials on a contract basis with commerical companies. During the year the pipeline transportation of Alberta and British Columbia metallurgical coals from the foothills to Vancouver has been under investigation. Also, a program is in progress to rank a number of non-corrodable pipeline linings as a function of the resistance to wear.

Air Cushion Vehicles

Over 100 operational hours have been logged on a small hovercraft which was purchased in October, 1971 to provide transportation at remote field sites during spring runoff. Although the vehicle fell short of requirements, considerable experience has been accumulated in the operation of small hovercraft over varied terrain and under extreme weather conditions. On this basis, a detailed specification has been drawn up for a small cargo carrying hovercraft which would be superior in most aspects to the present range of small air cushion vehicles (ACV's). The specification has been submitted to the National Research Council in an attempt to influence the future development of the small ACV industry in Canada. Also, it is hoped that the specification would initiate a tripartite development of a small ACV prototype, with SRC providing field experience and testing facilities, the National Research Council collaborating with industry to finance and construct prototypes. At the present time, the National Research Council is investigating the crop spraying possibilities of small ACV's.

WATER

Desalination of Water by Natural Freezing

In much of the settled area of Saskatchewan brackish or saline groundwater is the only reliable water source. Most of it can be used if necessary, but it has a bad taste, it causes damage to water systems, and it reduces the profitability of livestock and poultry operations. Desalination of this water would improve the quality of life on Saskatchewan farms and small communities. Much of the research in other parts of the world has been devoted to the development of processes which are economical on a large scale. Hence, the commercially available processes become very expensive at low

capacities because the equipment is complex and skilled operators are usually required. The Division has investigated freeze desalination processes using natural refrigeration. Three processes, i.e., reservoir freezing, layer freezing, and spray freezing have been studied.

In reservoir freezing, a shallow reservoir filled with brackish water is allowed to freeze naturally during the winter. About 75 percent of the salts are excluded from the ice and concentrate in the unfrozen brine beneath the ice. In the spring the brine is discarded, and the ice melt is stored for use during the year. The study of reservoir freezing is essentially complete, except for field trials. The only work done during the 1971-72 winter was a continuation of the experiments with groundwater in 100 x 100 foot lined and unlined reservoirs. Yields of 9.5 and 19.5 imperial gallons per square foot and purification efficiencies of 87 and 77 percent were obtained in the unlined and lined reservoirs, respectively. The low yield and high purification efficiency in the unlined reservoir occured because of an unusually thick snow cover.

In layer freezing, a block of ice is built up by freezing successive layers of brackish water on previously frozen ice. The initial drainage is more concentrated than the feed water, causing the remaining ice to be desalinated. This process has some technical advantages over reservoir freezing, but appears to be more expensive, hence work on this process has been discontinued.

The major research effort during the year has been on spray freezing. Spray freezing is analogous to layer freezing except that an unconfined ice mound is built up by continuous spraying during the winter.

Two field tests of spray freezing were conducted during the 1971-72 winter. In the first, 281,000 imperial gallons of water containing 4,500 ppm sodium chloride were sprayed into a 130 x 130 foot butyl membrane lined basin over a 53 day period. About 85 percent of the input was recovered as water containing less than 1,000 ppm sodium chloride. In the second test, tap water was sprayed into an unlined basin of the same size with the objective of determining the amount of water which would be lost by seepage during the freezing and melting period. Because of freeze-up problems, only 150,000 imperial gallons were sprayed. Thirty-eight percent of this was lost by seepage.

Capital and operating costs of spray freezing were estimated and are given in the following table. These costs are based on design parameters not yet confirmed experimentally, but it appears that the economics of desalination by spray freezing compare favorably with those for other desalination processes.

Annual Capacity, Million Imp. Gal.	Capital Cost, Dollars	Operating Cost, Dollars per 1,000 Imp. Gal.
1	7,630	1.09
10	43,500	0.64
100	260,000	0.405

Field studies of desalination of brackish groundwater by spray freezing are planned for the 1972-73 winter at three sites — Blucher, Bruno, and Armley. Each site will consist of a production well, two spray freezing basins, a product storage reservoir, and a brine holding pond. Butyl membrane liners will be installed in one freezing basin at each location, in the storage reservoirs at Bruno and Armley, and in the brine holding ponds at Blucher and Armley.

Idylwyld Underpass Storm Drainage Study

The construction of the Idylwyld Underpass on the north side of Saskatoon was completed in 1969. This is the first freeway underpass in Saskatchewan. The consulting engineers were not able to obtain reliable data on storm intensities for various durations and return periods and so they had problems in designing the storm drainage system. Moreover, the information they obtained indicated that the present design philosophy is toward using longer flood return periods to offset uncertainties in the expected values of storm runoff. North American cities often use a 50 year return period for their drainage problems; a costly design based on a 50 year return period probably is not justifiable for a small prairie city.

The site of the Idylwyld Underpass, with its comparatively simple storm drainage system, was instrumented to yield instantaneous rainfall and storm water outflow data. This provides valuable information for the design of similar and more complex urban flood basins. The Saskatchewan Department of Highways has been interested in the program and has provided funds for instrumentation purchases. The instrumentation consists of seven tipping bucket rain gauges, a number of standard 3-inch MSC rain gauges for comparison, four full pipe flow meters and a water level recorder. Data are collected by a computer-controlled data acquisition system and recorded on punched paper tape. An emergency power supply has been installed to insure continuous records in the event of a power failure during a storm.

Soon after the freeway was put into operation, the storm drainage system functioned abnormally because of a sand and silt build-up in the pipe network which resulted from erosion of the ungrassed slopes in the 16 acre catchment area. Erosion from the slopes was checked during the summer of 1971 and the silt load was removed from the storm sewers in the early summer of 1972. Reconnaissance of the storm sewer network has confirmed suspicions that the flood routing studies will not be possible because of poor invert alignment of the pipe network. Both rainfall and runoff data have been accumulated during the summers of 1971 and 1972 and a progress report has been prepared.

IHD Study of Big Quill Lake

In 1965 a data bank of hydrometeorological information was started to give a statistical basis for analysis of the resources of Big Quill Lake. The project was designated as one of Saskatchewan's contributions to the International Hydrological Decade Program (IHD). Big Quill Lake is located approximately 100 miles east of Saskatoon and a similar distance north of Regina. The

lake drains an area of approximately 1,000 square miles. The surface area of the lake is 100 square miles but this varies seasonally by 10 to 20 percent. This variance, due to its shallow depth, depends on the annual hydrological balance and on the wind speed.

The primary purpose of the study is the investigation of the hydrological balance of a large, shallow, highly saline internal surface drainage basin in sufficient detail to permit economic decisions to be made for planning the future potential of the lake. Interest centers around the 20 million tons of sodium sulphate and magnesium sulphate in solution in the lake. It also has social implications for recreation, wildlife and as a water supply. Basic hydrological, meteorological, chemical and geological data have been collected since 1966 to establish a data bank. This is required to form a statistical basis for the prediction of the hydrological balance and for the determination of the relationship and magnitudes of the dominant parameters: streamflow, precipitation, evaporation and underground water flow.

Historical records of the lake and of the basin have shown that in the past the lake depth has been decreasing while the salinity has been increasing. This has not followed a regular pattern. In fact, the volume of water is dependent upon two meteorological parameters: evaporation and summer precipitation. It is possible, knowing the trend of these two parameters, to make a two-year prediction of the lake depth. This limited prediction is not sufficient, however, to allow adequate prediction for economic potential. The instrument network around the lake is being used to study methods of increasing our understanding of the climatic trends.

Analysis of the winter water budget, which includes spring runoff, for the period of 1963-1972 shows that water flowed out of the lake as groundwater during the winters of 1963, 1964, 1965 and possibly 1968. Inflow into the lake occurred in the remaining years: 1966, 1967, 1969 and possibly 1971. These observations agree with the geohydrology observation well data for the general area (maintained by the Geology Division) and the chemical analysis of the lake water.

Small Drainage Basin Studies

The development of surface water resources is a major problem in the province of Saskatchewan. Insufficient rainfall over large areas and low winter precipitation make it imperative to evaluate the available water resources to formulate better management procedures. The growing livestock population and the manufacturing industry have placed an increasing demand on the water resources of the province. The farm communities derive much of their water supply from farm dugouts, sloughs and ponds which catch water mostly from spring snowmelt runoff. The P.F.R.A. is actively engaged in a program of technical and financial assistance to farmers in the construction of dugouts. At present, there are over 54,000 dugouts in the province. Many watersheds which are sources of surface runoff are generally characterized by immature drainage and lack of relief with inadequate snowfall during the winter months. On the other hand, many of the dugouts or dams wash out due to excessive runoff or become useless due to excessive silting. These pose problems to an efficient management of water supply to farm dugouts. In the prairies one is confronted with the problems of optimizing the watershed yield by proper land use methods and modification of snow cover using snow fences. The surface water program of the Division is attempting to solve these problems in particular and to understand prairie hydrology in the provincial context in general.

The Division initiated a study of small drainage basins in 1961 at Floral and since has extended the program to include watersheds at Delisle, Wilkie and Wynyard. This is a Canadian contribution to the International Hydrological Decade. The objectives of the study are:

1) to relate total runoff from a small drainage basin (10 square miles or less) to the watershed parameters such as area and topography.

2) to relate peak runoff to such parameters as spring weather conditions, distribution of snow drifts, vegetation in the channel and channel orientation.

3) to determine 'similarity' relations to apply the results of the basin research to ungauged watersheds in the province.

Important relations among the physical parameters of prairie watersheds have been derived using the data collected over the years. The mechanisms controlling the snowmelt and runoff from the watersheds with depression storage have been studied and the similarity relations are being worked out.

A very accurate method of stream gauging using fluorescent dyes has been developed and used with success in some of the watersheds. This does not require weirs and flumes at the gauging site and so can be used at several places. This technique will be used to monitor small ungauged drainage basins in a province-wide survey.

Stream Gauging using Fluorescent Dyes

By mid-April, ten injection units and ten sampling units, all of new design, were completed. The plan to install these at Gessell's watershed (Delisle) was disrupted by the very early snowmelt on this watershed. Accordingly, the centre of field operations was moved to Quill Lake, where snowmelt occurred about two weeks later. Due to unprecedented flood heights in this area, the equipment suffered severe flood and ice flow damage. This left much of the equipment in an unreliable state for the duration of runoff studies, and considerable effort was necessary to conduct a joint program of instrument repair and runoff data acquisition. The sampling units proved to be quite reliable, but the injection units were most erratic, and it is in this area that the greatest effort will be required in future.

At the present time, slight improvements are being made to the sampling unit, and a completely new design of injection is being tested. Initial studies indicate that this method should be much more reliable and uniform in delivery rate.

Further tests have been conducted with polyurethane insulation, and it has been established that, with 2" of this insulation in the equipment, the heat from the 3 watt control system will be sufficient to prevent internal freeze-ups. This will eliminate the necessity for catalytic heaters, which proved to be very troublesome under spring conditions.

Slough and Pothole Studies

A thorough understanding of the water balance of sloughs and potholes is necessary for various reasons. The efficient management of watersheds, supply of fresh water for farm use, the controlled drainage of sloughs for agricultural purposes and water fowl development require a knowledge of the hydrology of sloughs and potholes. The Council started the study in co-operation with the Canadian Wildlife Service in 1961-62. Field work was begun in 1964 with 125 sloughs under study in five different areas of the province. It was approved as an IHD project in 1965. The objectives of the project are:

1) to assess small reservoirs as sources of surface water and groundwater recharge.

2) to evaluate evaporation from various types of sloughs.

3) to determine if meteorological parameters can be used to predict the permanence of sloughs.

A permanent slough at Floral and a lined dugout at Blucher were chosen for a detailed study of evaporation. An accurate method of computing evaporation has been developed which incorporates the size and shape of the water body. This method has been applied successfully to reservoirs of areas ranging from a fraction of an acre to thousands of acres. Thermal response of sloughs and the effect of shelter on the rate of evaporation have been studied in detail and the results are published elsewhere. It has been shown that sheltering a pond may increase the rate of evaporation under certain conditions. Simultaneous measurements of windspeed and temperature profiles are made over a water surface to study their mutual relationship and their influence on evaporation. The results show that the mass transfer coefficient can be given as a function of the stability of air. In view of the increasing interest in fish farming in the province, the results from this study will help formulate guidelines in the selection of the right type of waterbodies for fish farming and in increasing their oxygen content. The study will also be useful in understanding the freeze-thaw cycles in reservoirs and the efficient disposal of pollutants in surface waters.

Reports

E 72-1 Proposal to establish a Potash Centre of Technology in Saskatchewan, W. H. W. Husband, January, 1972.

E 72-2 Program to Evaluate, Interpret, and Correlate Ground Control Measurements in Potash Mines in Saskatchewan. Annual Report, April 1, 1972 - March 31, 1972. C. A. Baar, March, 1972. (Confidential).

E 72-3 Big Quill Lake. Annual Report 1971. A Joint Federal-Provincial ARDA Program. J. M. Whiting. April, 1972.

E 72-4 The Potential of Helically Ribbed Pipes for Solids Transport. W. Schriek, L. G. Smith, D. B. Haas, W. H. W. Husband, April, 1972.

E 72-5 Program to Evaluate, Interpret, and Correlate Ground Control Measurements in Potash Mines in Saskatchewan. C. A. Baar, July, 1972. (Confidential).

E 72-6 Dangerous Application of Laboratory Parameters to the Design of Deep Potash Mines. C. A. Baar, May, 1972. (Confidential).

E 72-7 The Long-Term Behaviour of Salt Rocks in Deep Salt and Potash Mines. C. A. Baar, May, 1972. (Confidential).

E 72-8 Determination of Stresses in Salt and Potash Mines for Application to Mine Design. C. A. Baar, June, 1972. (Confidential).

E 72-9 Salt and Wetting Perimeter Complications to Standard Evaporation Calculations. J. M. Whiting, May, 1972.

E 72-10 Pilot Plant Facilities for Hydraulic Transport of Solids. L. G. Smith, W. Schriek, W. H. W. Husband, C. A. Shook, July, 1972.

E 72-11 Some Experimental Results from a Feasibility Study of a Long Distance Pipeline to Carry Potash. W. Schriek, L. G. Smith, W. H. W. Husband, J. H. Hudson, July, 1972.

E 72-12 Some Experimental Studies of the Effect of Particle and Fluid Properties upon the Pressure Drop for Slurry Flow. C. A. Shook, D. B. Haas, W. H. W. Husband, W. Schriek, L. G. Smith, July, 1972.

E 72-13 Desalination of Brackish Water by Spray Freezing. J. W. Spyker and W. H. W. Husband, July, 1972.

E 72-14 A Hydro-Meteorological Data Recording System. J. M. Whiting, July, 1972.

E 72-15 Spray Freezing of Brackish Water. Progress Report 1971-72. A Joint Federal-Provincial ARDA Program. J. W. Spyker, September, 1972.

E 72-16 The Mineral Industry of Saskatchewan. W. H. W. Husband, October, 1972.

E 72-17 Transfer of Solids Pipeline Development Program for Canadian Commodities from Canadian Transport Commission and Transportation Development Agency to Private Industry. W. H. W. Husband, W. Schriek, October, 1972.

E 72-18 Actual Geological Problems in Saskatchewan Potash Mining. C. A. Baar, October, 1972.

E 72-19 Specification for a Small Cargo-Carrying A.C.V., D. Eyre, J. M. Whiting, L. Hesterman, J. Jones, N. Nicolichuk, October, 1972.

E 72-20 The Wynyard Watershed Report No. 2. A Joint Federal-Provincial ARDA Program. J. M. Whiting, December, 1972.

E 72-21 Proposal to Establish an Industrial Minerals Centre of Technology in Saskatchewan. W. H. W. Husband, December, 1972.

E 72-22 How the Mining Methods were Improved in the Soligorsk Potash Mines (U.S.S.R.) Translation by C. A. Baar, December 1972.

REPORT OF THE GEOLOGY DIVISION

by R. G. Arnold

GROUNDWATER GEOLOGY STUDIES

Groundwater geological studies are continuing as a joint Provincial-Federal project under the Agricultural and Rural Development Act (ARDA). The staff involved in this project are:

Supervisor: E. A. Christiansen, Associate Research Officer

Laboratory Assistants: W. C. Ross, Assistant Research Officer; M. Chu, Technician

Summer Assistants: Two University of Saskatchewan students

The continuing objective of the groundwater geological studies is to locate fresh water bearing sands and gravels (aquifers) in the settled area of Saskatchewan. Test drilling to delineate major subsurface aquifers was completed in 1970, and 12 maps summarizing the results have been published (Fig. 1). Publication of the remaining maps has been delayed so that additional data obtained from the lignite coal inventory test drilling program can be included.

The mapping of glacial deposits and their associated aquifers was continued during the year. The areas studied (Fig. 1) were Rosetown (72-0), Wynyard (72-P), Melfort (73-A), and Saskatoon (73-B). Determination of the carbonate content of glacial tills as an aid in stratigraphic correlation was continued. All data are summarized in computer processible form for future analysis. One of the major regional aquifers in the inhabited portion of the province is the formation lying between the bedrock surface and overlying till. This aquifer has been named the Empress Group, and because of its significance for water supply has been mapped areally and stratigraphically.

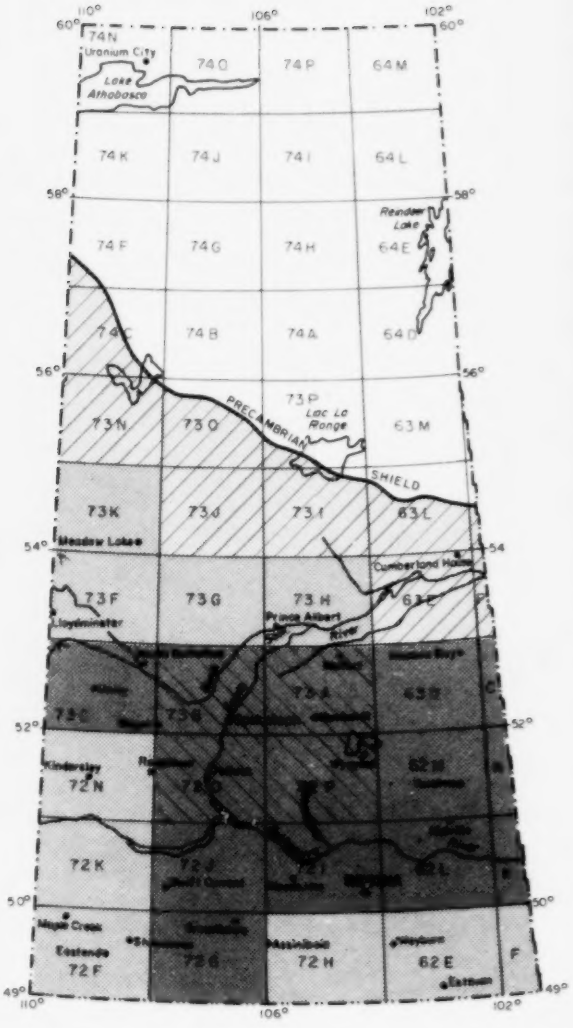
A new Geological Map of Saskatchewan was published during the year at a scale of 1:1,000,000. Production of the map was a joint project between the Saskatchewan Research Council and the Saskatchewan Department of Mineral Resources. The geology of the Sedimentary portion of the Province was compiled by the Council and Precambrian geology was complied by the Department of Mineral Resources. All cartographic work on the map was carried out at the Council.

Publications

The Empress Group in southern Saskatchewan. Can. Jour. Earth Sci., 1972, V. 9, p. 353-360 by S. H. Whitaker and E. A. Christiansen.

Cross-section of drift and bedrock between Condie and Craven, Saskatchewan. Sask. Res. Council, Geol. Div. Cross Section No. 1 by E. A. Christiansen.

Geological Map of Saskatchewan, 1972. Dept. of Mineral Resources, Regina and Saskatchewan Research Council, Saskatoon, compiled by S. H. Whitaker and D. E. Pearson.



Area covered by SRC Test Drilling Program

73B National Topographic System Map Sheet Reference

Published in Geological map of Saskatchewan, 1972

Maps published

Maps to be published

Surficial deposits and aquifers mapped in 1972

Fig. 1 - Map Showing Status of Groundwater Geology Project

SINKHOLE IN EASTERN SASKATCHEWAN — HOWE LAKE

The geological structure beneath Howe Lake, about 2 miles south of Tuffnell, was investigated by test drilling through 40 inches of ice in February, 1972. The base of the alluvium beneath the lake is funnel shaped (Fig. 2) and is more than 457 feet thick and 150 feet in diameter in the center of the lake (Fig. 3). The structure is interpreted as a collapse feature resulting from the removal of salt from the Prairie Evaporite Formation underlying

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Publications

The Empress Group in southern Saskatchewan. Can. Jour. Earth Sci., 1972, v. 9, p. 943-960 by S. H. Whitaker and E. A. Christiansen.

Cross-section of drift and bedrock between Coronach and Craven, Saskatchewan. Saskatchewan Research Council Publication No. 7 by E. A. Christiansen.

Geological Map of Saskatchewan, 1972. Dept. of Mineral Resources, Regina and Saskatchewan Research Council, Saskatoon (compiled by S. H. Whitaker and D. B. Peterson).

Area covered by SRC Test Drilling Program

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the lake at a depth of about 2900 feet. A seismic study was conducted in the vicinity of the lake by Dr. D. Gendzwill, Department of Geological Sciences, University of Saskatchewan. The National Research Council provided financial support for the project.

STRATIGRAPHY OF THE QU'APPELLE VALLEY

Studies show that the Qu'Appelle Valley was formed 12,000 to 14,000 years ago and was initially 100 to 300 feet deeper than at present. Throughout its history the valley has been a major groundwater discharge sink and has been continually receiving sediments from the adjacent uplands so that now the original valley is half filled with alluvium. The results of this study form a basis for land use and planning of the valley.

The results of studies to date were published in guide book form as indicated below. Financial support for field work was provided by the National Research Council.

Publications

Guide book on the "Geology and its application to engineering practice in the Qu'Appelle Valley area". Edited by E. A. Christiansen. Published in 1972 by the Regina Geotechnical Group, Saskatchewan Geological Society and Saskatchewan Research Council.

Stratigraphy of the Fort Qu'Appelle vertebrate fossil locality, Saskatchewan. Can. Jour. Earth Sci., 1972, v. 9, p. 212-218 by E. A. Christiansen.

URBAN GEOLOGY OF SASKATOON

Test drilling in Saskatoon was carried out initially through a Saskatchewan Research Council grant to Professor W. G. Watt of Civil Engineering at the University of Saskatchewan. The initial results were so interesting that six additional test holes were drilled by the Council. The drilling has revealed that Saskatoon is underlain by a number of preglacial valleys, by salt collapse structures showing more than 200 feet of vertical settling over one half mile widths and by a weathered zone in glacial sediments showing more than 40 feet of carbonate leaching.

The geology of the fossil bone site just north of Saskatoon is being investigated to provide a geological framework for C. D. Harrington, Curator of Zoology, National Museum of Canada, who is studying the vertebrate paleontology of the area.

INTERNATIONAL GEOLOGICAL CONGRESS

A guide book was prepared for the International Geological Congress field trip C-22. In this excursion the landforms, stratigraphy and glacial history of the southern portion of the three prairie provinces were examined.

Publication

Quaternary Geology and Geomorphology between Winnipeg and the Rocky Mountains, Int. Geol. Congress Field excursion C-22 Guidebook. By N. W. Rutter and E. A. Christiansen, 1972.

GROUNDWATER INFORMATION SERVICES

Personnel: W. A. Meneley, Associate Research Officer
E. A. Christiansen, Associate Research Officer
S. H. Whitaker, Associate Research Officer

During the 1972 reporting period, the Geology Division received about 200 written requests for groundwater information. In addition, at least 300 requests were processed by telephone or office interviews. These requests now represent a substantial work load.

Field trips, short courses, lectures and displays were organized throughout the year to provide training and information for personnel in government agencies and groundwater users. A list of information activities is given below.

Groundwater field day, Shaunavon, January 10, 1972; presented by W. A. Meneley
Groundwater field day, Ituna, January 12, 1972; presented by W. A. Meneley
Groundwater field day Humboldt, January 14, 1972; presented by W. A. Meneley
Groundwater field day, Unity, January 17, 1972; presented by W. A. Meneley
Groundwater field day, Meadow Lake, January 19, 1972; presented by W. A. Meneley

Public Health Inspectors Short Course, March 1, 1972; presented by W. A. Meneley and S. H. Whitaker.

Blackstrap Lake Ice Cover Parking Lot, April 5, 1972; presented to Saskatoon Geotechnical Group by W. A. Meneley.

International Geological Congress Field Excursion A26, Hydrogeology of the Rocky Mountains and Interior Plains, August 11-19, 1972; W. A. Meneley, co-leader.

Aquifer systems in a Glaciated Terrane, August 22, 1972; presented to the Hydrogeology Section, International Geological Congress at Montreal by W. A. Meneley.

Geology and water well construction; field tour for high school students at Bruno, October 12, 13; presented by W. A. Meneley.

Hydrologic instrumentation, data processing, geology and well construction practice; October 5, 16, and 18; office visits and field demonstrations for Saskatchewan Institute of Arts and Science Water Science Technology students presented by W. A. Meneley and E. J. Jaworski.

Geology of the Qu'Appelle Valley. Lecture presented to the Regina and Saskatoon Geotechnical Groups, E. A. Christiansen, 1972.

NATIONAL AND PROVINCIAL COMMITTEES

Associate Committee on Geotechnical Research of the National Research Council of Canada; E. A. Christiansen.

Canadian Advisory Committee on Remote Sensing; E. A. Christiansen.

Geological Association of Canada, Councillor for Urban Geology; E. A. Christiansen.

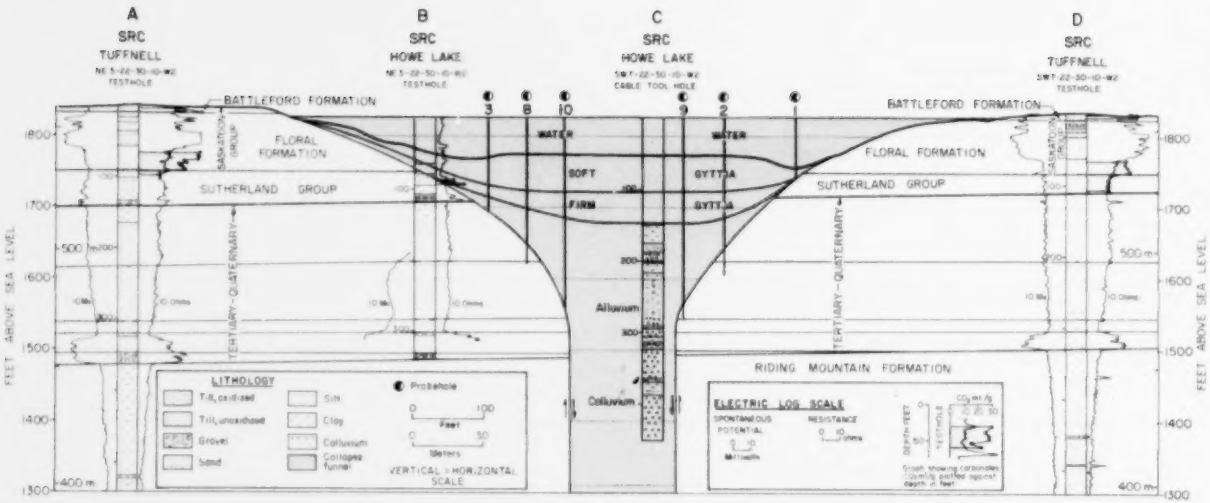


Fig. 2 - Cross Section of Howe Lake Sinkhole

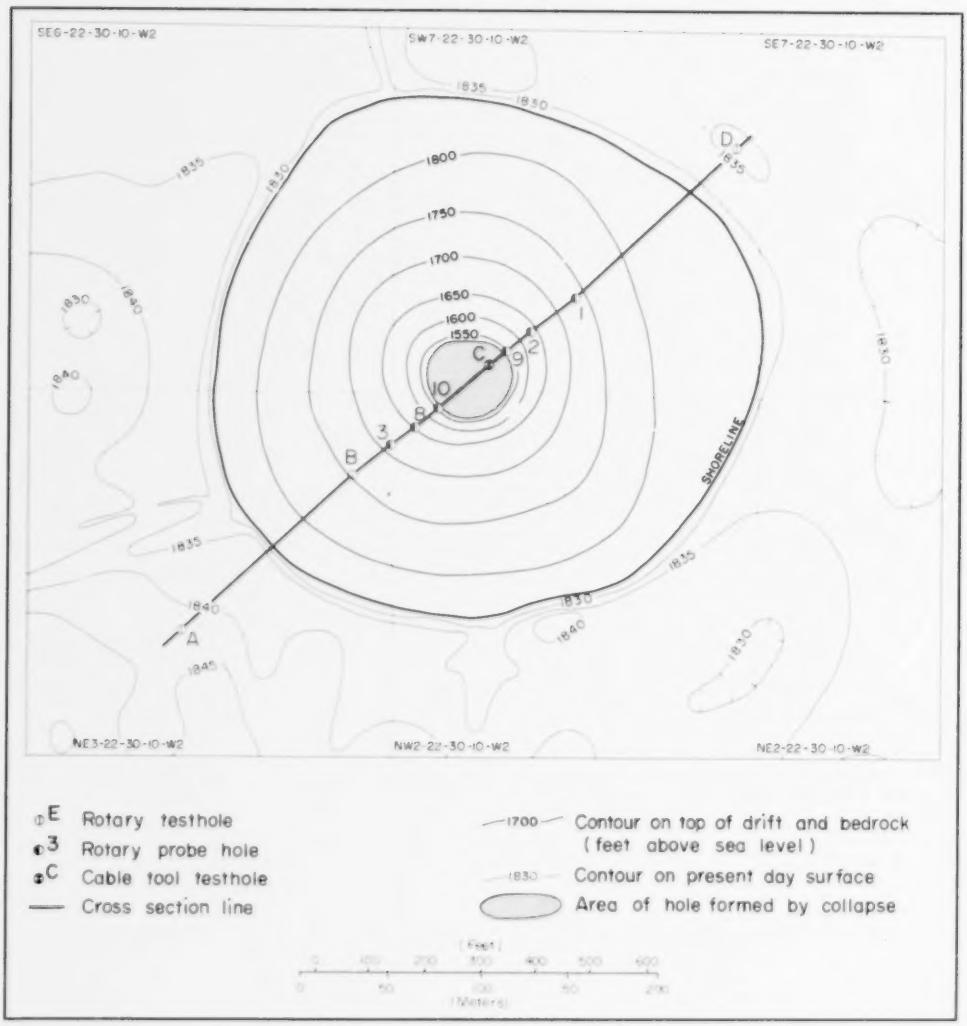
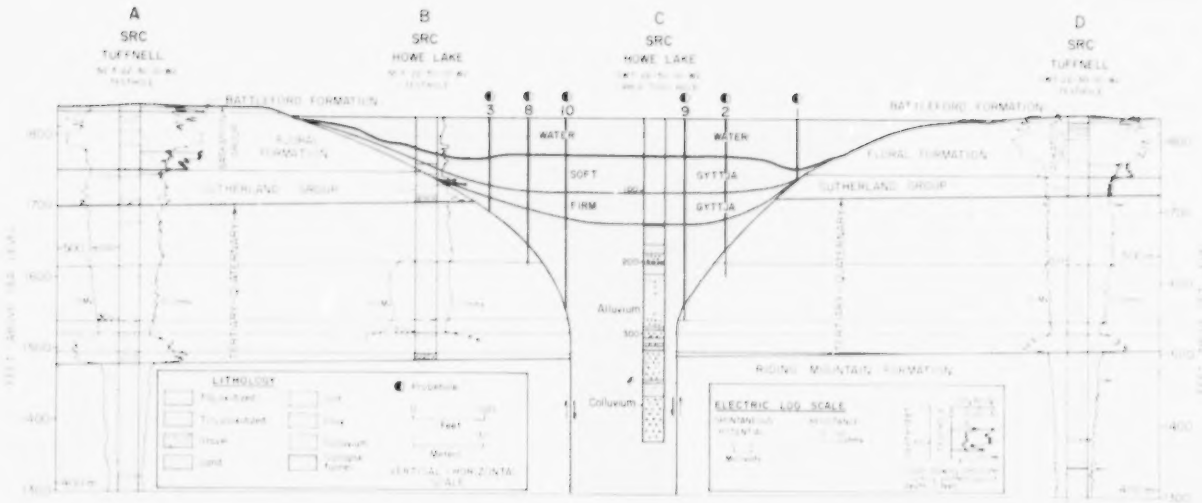


Fig. 3 - Contour Map of Howe Lake Sinkhole



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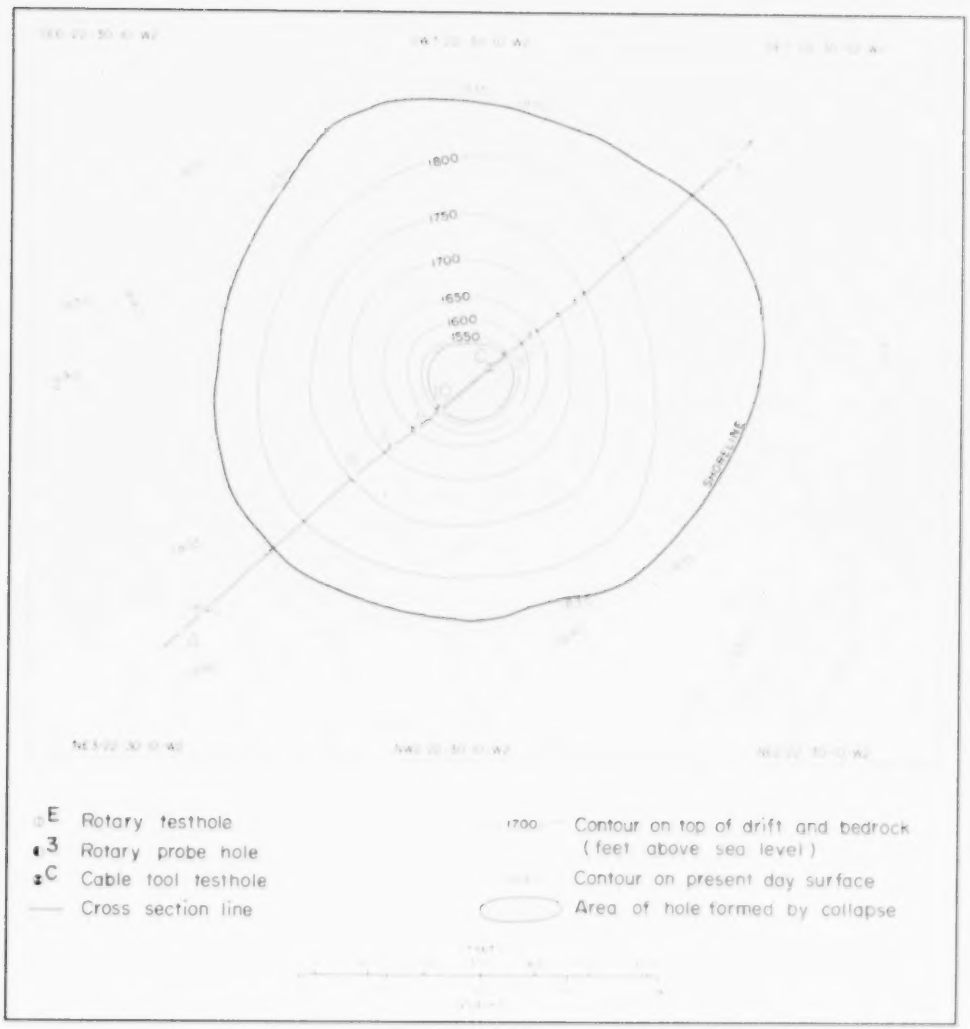

Fig. 3 - Contour Map of Howe Lake Sinkhole

Advisory Board for Water Sciences Technology, Saskatchewan Institute of Applied Arts and Science, Saskatoon; W. A. Meneley.

GROUNDWATER HYDROLOGY STUDIES

This is a joint Provincial-Federal project under the Agricultural and Rural Development Act (ARDA). The personnel involved in the project are:

Supervisor: W. A. Meneley, Associate Research Officer
Assistants: E. J. Jaworski, Technician
G. D. Sorenson, Technician

Investigations have continued in evaluating the groundwater resources of Saskatchewan. During the past year work has been concentrated on the following projects.

Conquest Project

Six continuously-recorded observation wells were constructed to monitor the performance of the Conquest area and to measure its effect on the adjacent irrigated area. Although irrigation will not be started for several years the observation wells were operational by January 1, 1972 to collect antecedent information about the hydrogeologic behaviour of the area prior to development. Evaluation of the hydrograph records will continue jointly with the Department of Agriculture staff.

Subsurface Storage of Desalinized Water

Initial experimental work was carried out jointly with the Engineering Division at the Blucher Experimental Site during the spring of 1972 to study the feasibility of storing desalinized water in a brackish water aquifer, and subsequently recovering the fresh water for use throughout the year. Although 120,000 gallons of fresh water were injected into a 4 inch diameter well without undue difficulty, the quality of the water recovered subsequently from the aquifer was rather disappointing. The experiment will be repeated next spring. Assistance was given to the Engineering Division in selecting typical locations for freeze-purification demonstration sites at Blucher, Bruno, and Armley. Supply wells were designed and constructed at each site to supply brackish water for the freeze purification operations.

Regional Observation Well Network

The regional observation well network continued to supply valuable information during 1972. The observed water level in the observation wells is closely related to the average precipitation (Fig. 4). The forecast water level tendency (Fig. 5) shows that by next spring the water level in wells less than 100 feet deep will be declining throughout most of the southern 100,000 square miles of Saskatchewan. The incidence of rural water supply problems may be expected to increase significantly by next spring. The increasing number of urgent requests for groundwater information we are receiving already supports this prediction. The continuing decline of water levels in southwestern Saskatchewan will tend to aggravate the water supply problems some residents are already experiencing in this area.

Water level information from the regional observation wells is finding increasing use to provide the background trend information necessary for interpreting water level observations adjacent to municipal well fields, waste disposal facilities, and other engineering works.

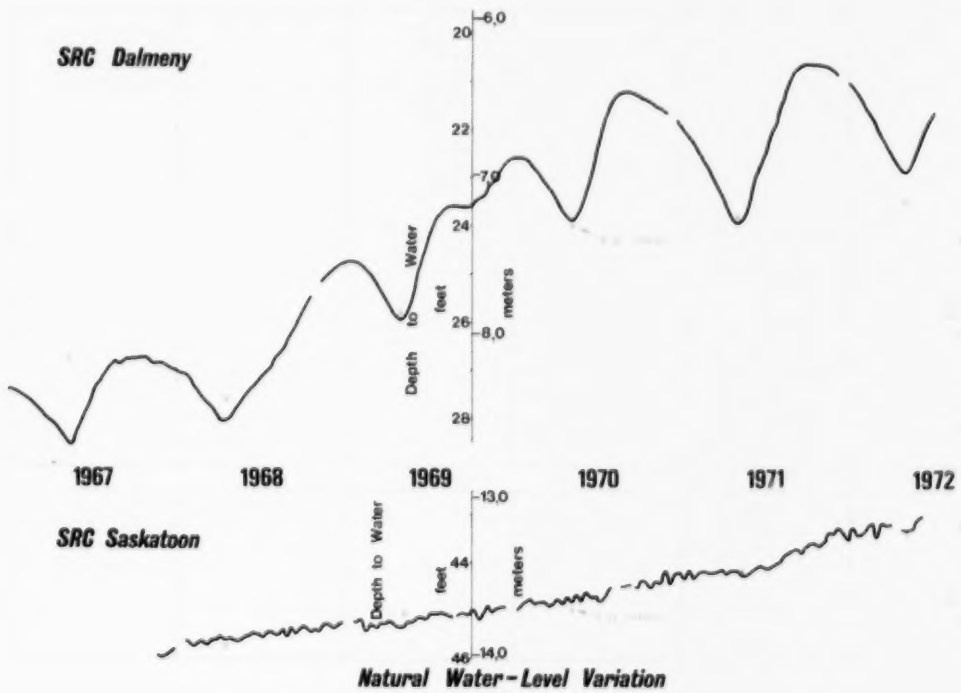

Fig. 4 - Relationship of Precipitation and Natural Water-level Variation

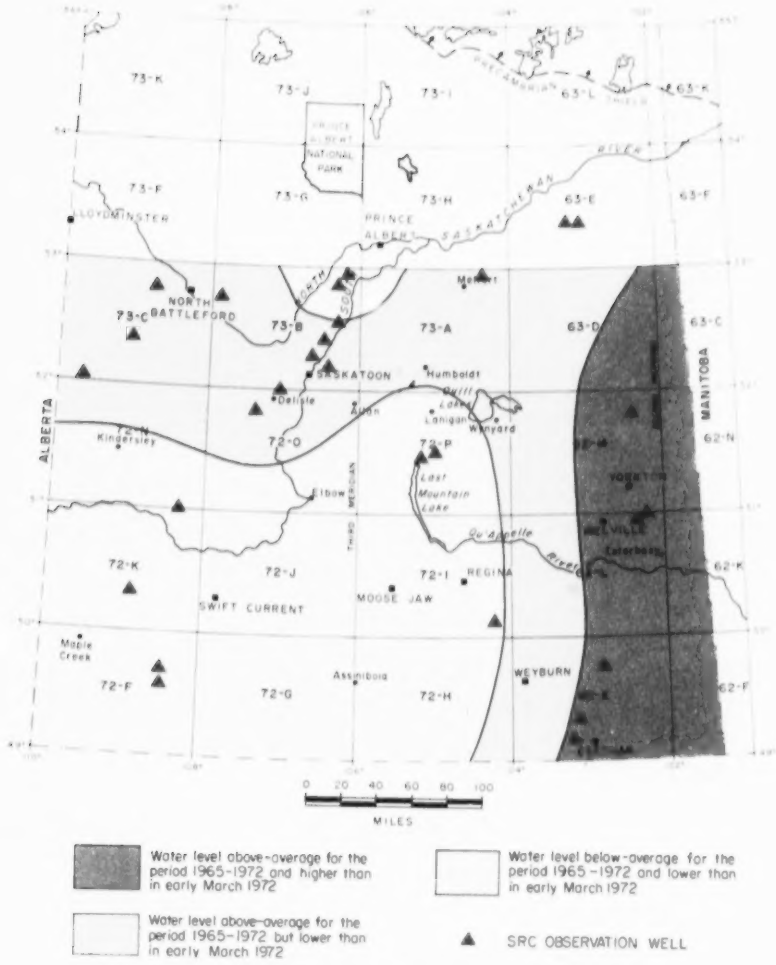

Fig. 5 - Forecast Water Level Tendency for Early March 1973

SASKATCHEWAN COAL EVALUATION PROGRAM

Program Co-ordinator: S. H. Whitaker, Associate Research Officer
Assistant: W. I. McPhadden, Technician
Summer Assistants: Two students

A three-year Federal-Provincial program to evaluate the coal resources of Saskatchewan began during 1972 with joint participation by the Saskatchewan Department of Mineral Resources, the Saskatchewan Research Council, and the Geological Survey of Canada.

The objective of the project during 1972 is to establish the geologic framework of the main coal bearing unit of the Province, the Ravenscrag Formation, in order to delineate those areas where detailed test drilling is required to establish coal reserves for the Province. Test drilling to accomplish this purpose was conducted during the summer of 1972 by three field parties; one from the Saskatchewan Department of Mineral Resources under the supervision of P. Broughton, one from the Geological Survey of Canada under the supervision of J. A. Irvine, and one from the Saskatchewan Research Council under the supervision of S. H. Whitaker. In addition, coal samples were collected by several different techniques for analysis by the Fuels Research Centre, Department of Energy, Mines and Resources in Ottawa in order to determine the most suitable sampling procedure for the 1973 field program. The leonardite content in these samples is being determined by the Chemistry Division of the Council. Compilation of results of experimental drilling, coring, and geophysical logging carried out in late 1971 in preparation for this program is nearing completion under the general supervision of J. H. Dyck of the Physics Division.

COAL PERMIT EVALUATION

Supervisor: S. H. Whitaker, Associate Research Officer
Assistants: W. I. McPhadden, Technician; and one summer assistant

A limited field program was conducted to complete an evaluation of coal permits held by the Saskatchewan Power Corporation that was begun in 1971. A limited number of analyses of samples from this program were done by the Chemistry Division of the Council.

CARTOGRAPHIC SECTION

Supervisor: W. E. Taylor

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CARTOGRAPHIC SECTION

Supervisor: W. E. Taylor

Draftsmen: C. G. Elias
C. H. Faulkner
J. C. Sardinha

The cartographic staff are responsible for the design, production and contractural supervision required for the production of Geology Division publications, as well as maintaining complete files of available topographic maps, aerial photos, E-logs, and accumulated field data. A program to assemble recent photo-mosaic coverage of the populated portion of the province at 1:50,000 is now complete. These are used extensively in geologic field work and have received wide circulation through other agencies and educational institutions.

During the past year, the staff conducted seminars and acted as consultants in scribing and color-separation techniques for several agencies including the Saskatchewan Power Corporation, the Saskatchewan Department of Mineral Resources, and the Forestry Branch, Saskatchewan Department of Natural Resources.

A major project included completion of a new Geological Map of Saskatchewan, in co-operation with the Saskatchewan Department of Mineral Resources.

It is expected that the remainder of a series of Groundwater Geology maps will be completed in two years as well as a comprehensive 1:1,000,000 base map of the province which will be the basis for future provincial mapping by the Saskatchewan Research Council.

PRECAMBRIAN GEOLOGY AND GEOCHEMISTRY

Geochemical Field Program

Supervisors: R. G. Arnold, Research Officer; D. R. Haughton, Assistant Research Officer

Technical Assistants: J. W. J. Smith, Z. Bilewski

Student Assistants: Eight University of Saskatchewan students

During the summer of 1972 a reconnaissance geochemical survey was conducted over a 1,200 square mile area in the southwest quarter of the Mudjatik area (74-B) which is approximately 110 miles northwest of La Ronge. Geologists of the Department of Mineral Resources were mapping the area and invited Council personnel to use their camp facilities and aircraft for the geochemical project. Without this support the project would not have been financially possible. The purpose of the geochemical program was to obtain experience in conducting such a program under Saskatchewan conditions and to provide background information on trace metals in geological materials for mineral exploration companies wishing to explore in the area. Exploration companies can use the geochemical data in conjunction with geological data to plan more effective mineral exploration programs than would be possible by using geological data alone.

The program involved a study of the concentrations of copper, lead, zinc, nickel, cobalt, molybdenum, uranium, mercury and iron in bedrocks, glacial overburden and lake sediments. Sample preparation involved drying, crushing, screening and a hot aqua regia digestion. Uranium was determined fluorimetrically, mercury by a flameless atomic absorption method and the remaining elements were determined by standard atomic absorption methods.

Each type of material was sampled for a specific purpose. Bedrock chips were analysed to ensure that fine-grained, disseminated mineralization is detected. Experience has shown that copper, lead, and zinc mineralization in some quartzites, arkoses and argillites from the Wollaston sedimentary belt, for example, are difficult to recognize. Glacial overburden samples were analysed to detect disseminated mineralization derived from glacially eroded bedrock mineralization. A number of fan-shaped mineralized zones in overburden have been discovered in Saskatchewan in the past, and systematic overburden sampling can indicate the approximate location of the parent mineralized zone in bedrock. Lake sediments are analysed to detect anomalously high concentrations of metals introduced into lakes by ground and surface waters. The metals are derived from oxidizing mineral deposits in the immediate lake environment. Metals introduced into lakes in aqueous solution precipitate and those introduced as adsorbed metals on suspended material settle and become incorporated in the bottom sediments where they are easily sampled.

Computer processing, the preparation of maps, and a report are in progress. Preliminary results of the study were made available to exploration companies in November 1972.

Laboratory Program

Supervisor: R. G. Arnold, Research Officer

Technical Assistants: J. W. J. Smith and Z. Bilewski

Co-worker: O. P. Malik, Post Doctoral Fellow

Chemical studies of natural and synthetic mineral systems initiated in previous years are continuing but at a reduced rate at the present time. Projects involving the chemical differences between "economic" and "barren" sulphide deposits and phase equilibrium studies in the iron-nickel-sulphur system have been completed. Current studies involve a continuation of studies of the distribution of manganese, cobalt, nickel, selenium and tellurium among common iron-sulphide and iron-arsenide gangue minerals found in copper-zinc ores. The results of such studies increase our understanding of ore forming processes and are, therefore, useful in formulating approaches to mineral exploration.

REPORT OF THE INDUSTRIAL SERVICES DIVISION

by I. S. Evans

The validity of the Division's objectives, has, as in previous years, been kept under constant review. Although these have not been changed, there is an increased awareness that the Division must attend immediately to, and even anticipate, the immediate and urgent needs of the provincial industrial community. In general terms the Division assists the Council in the attainment of its broad objective of improving the economy of Saskatchewan by increasing the technical, industrial and entrepreneural capabilities of industry. This is achieved by:

— Making scientific and technical information available to industry;
— Fostering the use of scientific and technical information by industry;
— Providing technical assistance to industry;
— Promoting the use of industrial engineering and management science by industry;
— Making the services of industrial engineers available to industry; and
— Engaging in information science.

In order to assist industry the Division provides the following services to industry:

— The Technical Information Service
a. Technical inquiries
b. Industrial engineering
c. Technological developments
— The Technical Assistance Program
— Assistance to industry in obtaining government grants to engage in research and development
— The Science-Service Library.

The programs undertaken jointly with the National Research Council, whose increased financial support is gratefully acknowledged, are described first.

The Technical Information Service

"It is vital to industry to ensure that existing and new knowledge is used to increase industrial productivity and to exploit new markets . . . Scientific and technological information is in fact now recognized as a major national resource and its effective utilization is a matter of immediate concern for Canada . . . The function of the Technical Information Service (T.I.S.) is to aid Canadian industry with emphasis on the small and medium sized companies. The Industrial Inquiries Section of T.I.S. responds to specific requests from companies for information and advice on technical matters.

The Industrial engineers who make up the Industrial Engineering Section provide advice to companies in such areas as production engineering, production planning and control, plant layout, materials handling, management, accounting and personnel." — Excerpts from the 1972 Report of the President of the National Research Council.

a. Technical Inquiries

The long established practice of endeavouring to visit each industrial establishment in the province once annually has been continued. Conventionally, the service aids industries on a free and confidential basis to solve their technical problems. These problems were recently described as being brilliantly disguised opportunities. For example, assistance is being given to two companies on the solution of a pollution problem. The problem costs the companies about $4500 per month. In both cases acceptable animal feeds are being sewered. The recovery and sales of these materials will increase company revenues by approximately $40,000 per year giving a total saving of almost $100,000 a year. It is also estimated that pay-out time for the recovery equipment required is less than two years. The variety of questions answered by the Service continues to be as wide as ever, ranging from the domestication of wild plants to the manufacture of animal feeds and components of agricultural machinery.

During the year 240 inquiries received written replies. Verbal replies and discussions are apprximately three to four times as many.

The Catalyst, which is one of the support services, was published monthly during the year and discussed the following subjects:

Research, Development and The Citizen
Recycling
Glimpsing At The Future
25th Anniversary and "Open House"
S.R.C. 25th Anniversary
Learning From Agriculture
Forecasting
Information Technology for the Future
Selling to Sophisticated Customers
Successful Innovation
Canadian Patents and Developments Ltd.
Nobelists' Thoughts

Publication of the Catalyst resulted in the distribution of 2,478 pieces of technical information

b. Industrial Engineering

Industrial engineering is defined by the American Institute of Industrial Engineers as the design and installation of systems to achieve a specific goal.

The nature of industrial engineering assistance is therefore fundamentally different from that offered by the Inquiry Section. Industrial engineering assistance is creative as well as corrective.

Industrial engineering also employs techniques which, in some cases, are relatively new to Saskatchewan in-

dustry. One such technique which was introduced over the last year, and which has met with considerable success, is time-lapse photography. This technique has been applied and assisted in the following areas:

— Determination of stenographic duties;
— Activity sampling in an implement manufacturing plant;
— Methods improvement on an assembly line;
— Materials handling in a machine shop;
— Crane utilization in a steel plant;
— Analysis of utilization of a library;
— Analysis of cutting aluminum plant;
— Methods improvement and materials handling in a bakery.

In the case of an assembly line operation the application of standard industrial engineering techniques assisted by analysis of time-lapse film enabled a 60% increase in output capacity from the crating area. Further review of the film enabled management to isolate and improve work stations in the assembly line which were not balanced. The effort resulted in considerable cost savings.

Analysis of time-lapse film on the utilization of large cranes in a steel plant showed that cranes were idle 60-70% of the time. Proper scheduling methods eliminated an expenditure of $50,000 for another crane.

When occasions permit, student projects are coordinated with industrial plants and the university. Such studies, which may range from one to three months, are directly related to the industry's problems and are beneficial to the students in fulfilling their graduate or under-graduate requirements. One study was organized during the past year involving the University's College of Business Administration and an implement manufacturer. The project was supervised directly by the Industrial Services Division and involved the application of industrial engineering techniques. The study involved activity sampling of the plant and the recommendations which followed in the final report were useful and implemented by management.

Installing Time Lapse Camera

Time Lapse Film Clip

Snow-machine Assembly

The examples of cost savings using only one industrial engineering technique already given will enable the reader to use his own benefit cost estimate of the value of the industrial engineering program to the province.

Further, the industrial engineers spend some considerable time with individual companies either doing or supervising industrial engineering work. During the year over 90 companies were assisted.

The benefits to be derived from these activities can only be estimated but it is felt that most people will agree that they are likely to exceed the calculable benefits realised from methods improvement.

During 1972 the pamphlet, Industrial Business Management, was published and the following topics were discussed:

The Exit Interview, Part 4
Effective Conversion to Direct Cost System
How to Find A Likely Successor
Patents and Inventions
Giving Credit to Your Customers
Housing's Wave of the Future
Warehouse Facilities Planning: Six Hard Rules For Uncertain Times
Marketing and the Better Mousetrap
Are Your Products and Channels Producing Sales?
Management's Legal Relations
What Are Your Overtime Costs?
ITLAP

Industrial Business Management satisfies the same needs in the industrial engineering field as the Catalyst does in the technical field.

c. **Technological Developments**

This service brings to the attention of industrialists excerpts from the current technical literature which are of immediate practical importance. These excerpts are computer selected against an industrialist's profile of interests. The provincial input to this program consists of making industrialists aware of the service and helping them to write their profiles.

The Technical Assistance Program

The opinion has been expressed before, and it has not changed, that on the whole Saskatchewan industry needs technical assistance more than it needs technical information. Indeed, Dr. W. R. Schneider, president of the National Research Council in his last report states, "A large proportion of the literature is in fact comprehensible only to experts in specific fields, and, in addition, the expert represents a source of information whose sum is greater than the individual parts which might be found in publications."

In the Division, technical assistance has taken the form of helping industry to apply the information and advice which it gives. During the year technical assistance has taken many forms including, for example, material selection, machine and tool selection, design assistance and encouraging industries to hire the appropriate technical staff. To this end the Division's staff has written advertisements, and helped employers in the selection process.

Assistance in Obtaining Federal Government Grants

This program is based on the belief that the innovative process depends almost equally on technology, capital and entrepreneurship. Since new technology is the product of scientific research, it is the Division's duty to increase the amount of new technology available to industry. Without science there can be no technology, without technology there can be no innovation and without innovation industry stagnates and dies.

Ideally industry should conduct its own research and develop its own technology. The National Research Council's Industrial Research Assistance Program and the Department of Industry, Trade and Commerce's Program for the Advancement of Industrial Technology both support research and development in industry.

During 1972 the Division's staff helped to form the North Eastern Alfalfa Dehydrators Research Association. On October 26th, 1972, the Association's laboratory was opened at Tisdale. Support from the Industrial Research Assistance Program will amount to about $146,000 for the first five years of the Association's effort. Approximately $60,000 per annum is now coming annually to Saskatchewan from the Industrial Research Assistance Program.

Help has also been given to companies seeking P.A.I.T. (Program for the Advancement of Industrial Technology) assistance worth about $110,000 in total. On numerous occasions companies have been helped to apply for and receive payments under the Industrial Research and Developments Incentives Act. To date, the highest single payment has been $57,000.

Science Service Library

The library continues to be the Division's contribution to the Council's internal effort. It is, however, made available to industry as far as the needs of the Council's staff permit. Unfortunately, it is under-utilized by industry.

The library's holdings concentrate on industrial engineering and business, hydrology, meteorology, Saskatchewan geology, chemistry and engineering and include 5000 books, 400 periodical subscriptions and 10,000 reports and pamphlets. Chemical Abstracts, Engineering Index, Rock Mechanics Abstracts and more than twenty-five other abstracts and indexing services are available.

In summary, the Division's efforts are a contribution towards increasing the technical and managerial strengths of Saskatchewan's industries. The means by which this contribution can be made more effective are under constant review.

REPORT OF THE PHYSICS DIVISION

by J. Maybank

Research activities of the Physics Division can be grouped under the following headings:

Meteorology
Geophysics
Instrumentation Services

Under the first two headings, work on some 7 projects has been carried out during the year.

Projects have received some financial support either by grant or contract from the following outside agencies: ARDA, the Canada Department of Agriculture, the Federal Department of the Environment, the Federal Department of Energy, Mines and Resources, the National Research Council, and the Division of Hydrology of the University of Saskatchewan.

The number of permanent staff increased to 10 in the past year. Mr. K. Yoshida was appointed to the permanent staff at the scientific level; his primary responsibility is to the pesticide pollution program. In addition Mr. R. Reich was appointed to fill a vacancy in the permanent technical staff. On the other hand, the appointment of Dr. T. P. Pepper to Director of the Saskatchewan Research Council and Dr. J. Maybank to succeed him as Head of the Physics Division, has left a further staff vacancy. Mr. B. Morrison, who recently retired from the Council has been employed periodically during the year as a consultant.

Dr. J. H. Dyck and Mr. J. L. Bergsteinsson continued their affiliations as research associates with the University of Saskatchewan, Departments of Electrical Engineering and Geography, respectively. The latter presently teaches one undergraduate and one graduate half-class in Climatology within the Geography Department program. Dr. Maybank continues as an Adjunct Professor to the University of Saskatchewan's Physics Department; he taught an undergraduate half-class in Meteorology during the spring term and a graduate class in Cloud Physics during the fall term.

Mr. Bergsteinsson was re-appointed to the Canadian Committee on Agricultural Meteorology for a second 3-year term. Dr. Maybank was appointed this summer to a 3-year term on the National Research Council's Associate Committee on Geodesy and Geophysics (Meteorology Subcommittee) and continues to serve on the N.R.C.'s Associate Committee for Agricultural and Forestry Aviation.

METEOROLOGY

Studies relating to the atmospheric environment constitute a major portion of the Physics Division program. This work has led to benefits in the fields of hydrology, agriculture, construction technology, and renewable resource management. Specific aspects of the research relate to pollution abatement, climatological analysis, weather probability estimates, irrigation system design and snow pack management.

Atmospheric Physics

The precipitation studies are related to the ever present concern in Saskatchewan with rainfall irregularity, and the closely related concern with hail and lightning from thunderstorms. Storms of this type provide on average about one third of Saskatchewan's annual precipitation, but the mechanisms responsible for their development are more erratic and hence less understood than those related to the frontal storms responsible for the remaining two thirds. Research at the Saskatchewan Research Council has been concentrated on studying the inter-relationship of the storm cloud growth and the build-up of electrical fields within it. This research has been partially supported by an Atmospheric Environment Service grant to Dr. Maybank.

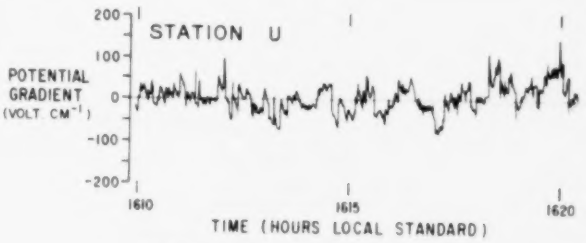

Fig. 1 - Lightning discharges and other changes in the atmospheric electric field observed during passage of a major hailstorm.

During the past year, data from previous summers' observations have been analysed in some detail. (See photo). The results show a regular increase in electric field activity and lightning discharge as the storm height increases for most storms. However, a specific exception appears to be that group of thunderstorms that have been designated supercell, or steady-state types. For them the lightning activity is very much lower than might be expected from the size and intensity of the system. It is hoped that these findings, when combined with other criteria, will give a better understanding of the development processes and lead to improved thunderstorm prediction and possible methods of hail reduction. The graduate student employed on this research recently received his Ph.D. degree from the University.

Climatological Studies

Operation of the Climatological Reference Station was continued as in previous years, with an increasing number of requests for weather data from this site being handled. The facilities are also used for field testing of new equipment, notably this year of a special, heated in-

strument shelter designed by the University's College of Engineering.

During the past year, improvements have been made in capabilities for handling data collected from the station. A computerized summary, prepared monthly, includes information on hourly temperature, dewpoint temperature, wind speed and direction, atmospheric pressure and bright sunshine, daily maxima and minima of air temperature and soil temperature, daily precipitation, evaporation and snow depth.

The Reference Station data has also been computerized. Past information has been entered so that current conditions can be quickly compared with historical records. Comparisons can be made as far back as 1914 in some cases. Certain statistical analyses are routinely carried out in connection with the climatic summary. (See photo).

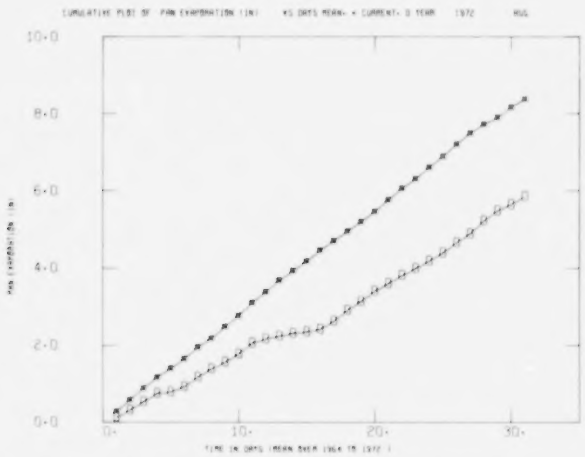

Fig. 2 - Computor plot of cumulative evaporation loss at Saskatoon during August, 1972 compared to mean August curve.

Extensive statistical investigations of the relationship between the yield of several wheat varieties and precipitation, temperature and sunshine are under way. This program is a co-operative one with the Crop Science Department, University of Saskatchewan, Saskatoon Campus.

With cessation of activities at Prince Albert climatological site, investigation of constant-flow, shallow burial water systems were transferred to the Council's site at 115th Street, Saskatoon. The initial phase of the study, which was partially sponsored by the Family Farm Improvement Branch, Saskatchewan Department of Agriculture, led to results that warrant further investigation of this low-cost technique for supplying water. More work is ongoing through the winter of 1972-73.

Work has begun on establishment of a climatological data bank containing 30 or more years of record from a network of key Saskatchewan weather stations. The data bank, currently containing more than 1,500,000 individual records, is a joint project of the Division of Hydrology, University of Saskatchewan and the Council. (See photo). Capital cost of acquiring Atmospheric Environment Service data was borne by the Division of Hydrology while data maintenance responsibilities rest with the Council.

Fig. 3 - Stored on these magnetic tapes are most of the climate observations taken in Saskatchewan over the past 70 years.

Pesticide Drift Investigation

This research, supported in part by an Extramural Research Grant from the Canada Department of Agriculture, is designed to study the amounts of herbicides and insecticides escaping the area to be sprayed and drifting downwind either as droplets or as vapour. From these findings recommendations are made to CDA of ways to reduce the hazards.

A series of field trials, begun two years ago, was continued this summer as a co-operative project with the CDA Station at Regina, and the Defence Research Establishment Suffield at Ralston, Alberta. Results of previous trials had established that the vapour drift from 2,4-D butyl ester was roughly ten times the droplet drift that occurred at the time of trial. The purpose of this year's trials was to investigate the improvement to be expected over the butyl ester by the use of the less-volatile octyl ester formulations. To date, problems associated with the radioactive tracer used have prevented complete analysis of these trials.

Field monitoring of 2,4-D amounts in the atmosphere was again carried out this year, using a network of six stations. Three of these were operated by the Saskatchewan Research Council, viz., at Naicam, Saskatoon and Rosetown, and three at Indian Head, Regina and Swift Current — by the Canada Department of Agriculture staff from the Regina Station. Techniques were carefully co-ordinated between the two agencies so that the results would be comparable.

Traces of 2,4-D esters were found on a number of days in late May, June and July at all stations. The level reached 0.01 $\mu g/m^3$ of 2,4-D butyl ester on 5 to 20 days (depending on the station) and 0.4 $\mu g/m^3$ as a maximum one day value. Smaller amounts of octyl esters were encountered on six days. Further analysis of the samples is being carried out by the University of Saskatchewan's Chemistry Department, the results of which are expected to indicate whether any 2,4-D amine was also collected in the samples. The preliminary results from all six stations were presented to the Western Weed Conference in December at Winnipeg.

A number of new foam and invert emulsion systems are being introduced by various companies; these are intended to reduce droplet drift, while at the same time producing equally good coverage in the swath. A few of these were tested in the field this summer, using aircraft spraying. Observations and initial analysis of samples collected downwind of the spray swath suggest that drift, while reduced, is not eliminated when foam herbicides are applied from aircraft. Furthermore, ground coverage appears less complete, but both these findings are preliminary.

The opportunity to pursue further the problem of aircraft spray drift occurred when a grant of $9000 was recently received from the National Research Council for this purpose. Sampling equipment is being designed and built with these funds, as the first stage toward carrying out next summer a series of more intensive field trials than have been possible in the past.

Publications

Bergsteinsson, J. L.: Analysis of heat transfer in a constant flow shallow buried plastic pipeline. S.R.C. Report P 72-3 (Confidential).

Grover, R., Maybank, J., and Yoshida, K.: Droplet and vapour drift from butyl ester and dimethylamine salt of 2,4-D. Weed Science *20*, 320-324 (1972).

Maybank, J. and Pakiam, J. E.: The electrical behaviour of severe hailstorms. Proc. Int. Cloud Physics Conference, p. 71; London, Eng., Aug. 72.

Pakiam, J. E.: The role of electrical processes in the thunderstorm of the Canadian Prairies. Ph.D. thesis, University of Saskatchewan, Division of Hydrology, October 1972.

GEOPHYSICS

Research in solid earth geophysics involves studies carried out in close co-operation with other Divisions of the Saskatchewan Research Council. The purpose is to provide information on Saskatchewan's groundwater and mineral resources and a fuller understanding of their development potential.

Groundwater Geophysics

The continuing objective of this program, which is supported by ARDA, is to engage in applied studies either to increase the chance of finding aquifers, or to contribute to the technology of water well development. Three main investigations were pursued in 1972.

The major project has been in processing Geology Division's hydrograph records, including digitizing, and computer editing and graphing these records to produce a data-set suitable for computer manipulation and analysis to help solve water supply problems in Saskatchewan. (See photo). To date, a backlog of 114 station-years of records has been processed and verified. This represents 64% of the data available until the end of 1972 from the Geology Division's observation wells in the Province. In addition, a backlog of 31 station-months of data from the Duck Lake Hydrological Observatory has been processed and verified and this represents 72% of the data available up to the end of 1972. Finally, utilizing computer facilities at the University of Saskatchewan, the feasibility of processing water chemistry data (which is available at the Council) has been demonstrated with special emphasis on graphical display of data. A Council report documenting a specialized form of graphical output is nearing completion.

Fig. 4 - Observation points from the water level records mounted on the board in the background are converted automatically into digital form via the card punch machine at the left.

The second groundwater activity has been with large-diameter farm water wells. We have continued to receive requests for information on the clam-shell well cleaning equipment and requests for assistance in using this equipment. In addition to dealing with 31 requests of this sort in the past year, we have placed water-level recorders (courtesy of the Geology Division) and water meters (for volume of water used) on two shallow large-diameter water wells at dairy farms. These producing wells are being observed to help determine the water consumption characteristics and the performance of such wells mainly with the view of maximizing the useful lifetime of wells of this kind.

Finally, detailed manuals describing the construction and design of some instruments built at the Council and used in the groundwater program are being prepared. The first of these on the "Heinze continuously-recording Volugraph" is nearing completion in 1972. This device has been used very successfully by geologists at the Council studying groundwater resources of the Province.

It may be of interest to note that 34 requests, including one for 200 copies from the U.S. Geological Survey, were received for "Application of Geophysical Logging to Groundwater Studies in Southern Saskatchewan" published in the Canadian Journal of Earth Sciences.

Lignite and Leonardite Logging Study

This co-operative program involving the Saskatchewan Department of Mineral Resources, the Canada Department of Energy, Mines and Resources, and the Divisions of Chemistry, Geology and Physics of the Saskatchewan Research Council was commenced last year. The evaluation of the use of geophysical borehole logging techniques as an aid for exploration of lignite in southern Saskatchewan has shown that logging methods are capable of: (1) determining the tops and bottoms of coal seams; (2) differentiating between coal and clay seams, where they are interbedded; (3) assisting the geologist in correlating information obtained from test drilling; (4) assisting in establishing and correlating the stratigraphy between testhole sites; and (5) assisting in estimating the volume of overlying earth to be removed (as part of a strip-mining operation) and the volume of coal in a given area.

Further, as part of this logging study, an attempt is being made to correlate geophysical borehole measurements with chemical data (obtained from laboratory analysis of samples by the Chemistry Division). Problems in this area are not yet resolved although some results look promising.

Publications

Dyck, J. H.: Review of the geophysical borehole logging project in leonardite and lignite in Southern Saskatchewan. S.R.C. Report P 72-1 (Confidential).

Dyck, J. H.: Application of borehole logging methods to lignite exploration in Southern Saskatchewan. S.R.C. Report P 72-4.

Dyck, J. H., Keys, W. A. and Meneley, W. A.: Application of geophysical logging to groundwater studies in Southern Saskatchewan. Canadian Journal of Earth Sciences, vol. 9, No. 1, pp. 78-94, 1972. (See also S.R.C. 1971 Annual Report).

Morrison, B.: Some naturally occurring electric fields. S.R.C. Report P 71-9.

Morrison, B. and Dyck, J. H.: Design of direct current resistivity surveying equipment including cable winder apparatus and resistivity control panel. S.R.C. Report P 72-2.

INSTRUMENTATION SERVICES

The electronics and precision instrument laboratories provide all Council divisions with facilities for designing, building and testing of electronic, electrochemical, and precision mechanical devices. Maintenance and servicing of these and all purchased equipment is also provided when requested. In addition, the services of the two laboratories may be made available for instrument construction and consulting for organizations outside the Council under contract arrangements.

Electronics Laboratory

During the year the electronics laboratory continued to provide consultation, design, fabrication and maintenance relative to electronic instrumentation in support of the Council's research program. In particular, maintenance requirements have increased from the preceding year.

A program requiring a major portion of the laboratory's resources was the design and development of an analog/digital data acquisition system for the Geophysics Laboratory. (See photo). This system is to be installed at the Geology Division's Duck Lake Hydrological Observatory and will measure and record deep earth temperatures to a maximum depth of 500 feet. It will have a capability of detecting temperature changes of less than 1/100 F. The output of the system will be in the form of punched paper tape for input to a computer and multipoint recorder analog chart for onsite visual inspection.

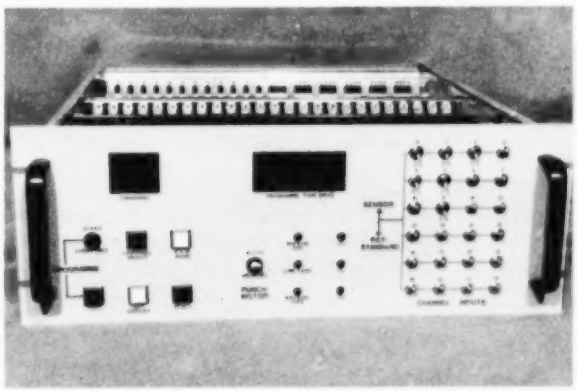

Fig. 5 - This programmer unit, developed by the Council's Electronics Laboratory, is designed to receive the signals from the various soil temperature probes and to control their subsequent recording in both analogue and digital form.

A second major project of the laboratory was the specification and installation of a four channel Carbon-14 dating system for the Chemistry Division.

In addition to in-Council activities numerous requests were received from external sources for consultation. Unfortunately, due to limited resources, the laboratory was unable to fulfil the majority of these requests. One contract which was undertaken, jointly with Dr. Dyck of the Geophysics Lab, was the investigation of static charge build-up at a Gulf Oil Tank Farm in the far north. At this time the investigation is incomplete but continuing.

Precision Instrument Laboratory

During the past year the activities of this laboratory can be divided roughly equally between the development of new products and the repair and maintenance of existing instruments. A small portion of time has been devoted to improvement in laboratories facilities. An important new addition this year has been the installation of a superior milling machine to permit considerably

more sophisticated metal shaping operations to be carried out. (See Photo).

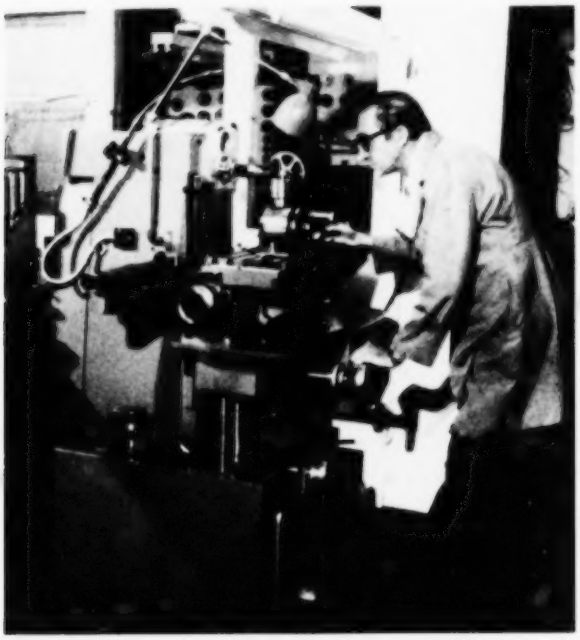

Fig. 6 - Milling machine recently installed in the Precision Instrument Laboratory.

The major project over the past year has been further development on the water level recorder being built for the Council's Geology Division. This involves the incorporation of the step motor developed last year together with a re-zeroing chart recorder that can be left unattended for periods of 6 months in Saskatchewan's climate. Prototypes have been shown to operate successfully and present plans call for construction of 25 of the final, modified version. These are being built in assembly line stages, with completion of the entire order estimated to be May of 1973. No water-level recorder on the market today seems nearly so efficient, nor so reliable for long period operation as these have been shown to be. Patentability of these recorders will be investigated.

A second project that occupied considerable effort was the building of an injection molding press to make parts for instruments quickly and economically. It has already been utilized for production of parts for various instruments.

Toward the end of the year, work commenced on the design and construction of 12 sampling stations to be used in the pesticide field trial program.

Modifications were made in the autumn to long period recorders used in the Marmot Creek Watershed Study, under contract with the Federal Department of the Environment.

THE UNIVERSITY PROGRAM

SCHOLARSHIPS

The Government of the Province of Saskatchewan offers graduate research scholarships tenable at either campus of the University of Saskatchewan. The purposes of the awards are to assist graduate students to prepare for careers in scientific and industrial research and to create interest in the development of resources and techniques that will advance the economy of the Province. The Council conducts the selection of the awards.

Awards valued at $3200 for the year beginning October 1, 1972 were made to:

(Mrs.) P. I. Tones — Biology, Saskatoon Campus
M. H. Sadar — Chemistry, Regina Campus
J. E. McClure — Geology, Saskatoon Campus

GRANTS IN AID

DEPARTMENT OF ANIMAL SCIENCE

1. The Use of Field Peas in Calf Milk Replacer Formulations

under the direction of
Professor J. M. Bell

Previous research in this department on the utilization of pea protein concentrates (PPC) and enzymatically-hydrolyzed pea flour (HPF) indicated that the young calf, under about two weeks of age has limited ability to digest the protein and energy components of peas. Partial hydrolysis of the starch effected improvement but failure to convert the starch completely to glucose was reflected in lower digestibility coefficients.

Further *in vitro* work was conducted with enzymes, and by other means such as pH modification, to develop techniques for improving the digestibility of *both* starch and protein in pea flour. A selection of proteolytic and amylolytic enzymes and appropriate time/temperature relationships were evolved, and in collaboration with the NRC and the Department of Dairy and Food Science, small scale commercial-type batches of hydrolyzed pea flour were prepared. Prior to spray drying, lard was homogenized into the liquid medium together with varying amounts of skimmilk such that three levels of pea flour replacement of milk solids were obtained. This program resulted in the production of milk replacer formulas containing 0, 25, 50, and 75 per cent of the dietary protein derived from enzyme-treated peas. The material was spray-dried in the facilities of the Dairy Pool, Saskatoon.

The four formulas thus processed are being fed to over 30 calves beginning at 3 days of age to obtain growth and feed utilization data.

In the second phase of this project, the direct feeding of enzymes is being investigated with a view to assessing the value of supplementing the limited enzyme capability of the new-born calf as a means of improving feed utilization and possibly obviating the need for hydrolysis of the pea flour prior to feeding.

Mr. Bruce E. Harvey is the graduate assistant working on these projects.

DEPARTMENT OF CHEMISTRY AND CHEMICAL ENGINEERING

1. Research in Fluid-Solids Systems

under the direction of
Professor C. A. Shook

This research is conducted in co-operation with the Engineering Division of the Saskatchewan Research Council and is concerned with problems which may be encountered in the design and operation of pipelines to transport solids. During 1971-72 funds from the Grant-in-aid were used to support a graduate student engaged in an investigation of transient flow in a pipeline.

Slurries of powdered limestone rheologically similar to lignite coal were allowed to settle in a horizontal pipeline for varying periods of time before being subjected to impulsive startup. The mixing process was found to be extremely rapid: less than two seconds was required to complete dispersal of the settled material. This indicates that few operating problems would be expected in restarting horizontal pipelines which had been shut down for some period of time.

A computer simulation of the behaviour of slurry pipelines was shown to predict the experimentally observed pressure changes very well. The velocity of propagation of a pressure wave was found to be markedly reduced by the presence of a stationary particle layer in the pipe. If the proposed theoretical explanation of this phenomenon is correct, a method for detecting such undesirable deposits can be devised. Work on this aspect of the problem is continuing.

The assistant on this project was Mr. L. T. Hubbard.

Publication

Hubbard, L. T. "Transient Flow of a Slurry." M.Sc. Thesis 1972.

2. Hydrogen Reduction of Sodium Sulphate

under the direction of
Professors W. J. DeCoursey and N. N. Bakhshi

Considerable quantities of sodium are produced in Saskatchewan and sold mostly for use in making draft paper pulp. Reduction of the sulphate to the sulphide would give a smaller bulk to transport and give a more valuable product, which might contribute to control of air pollution from pulp mills. Previous work gave promising results, as described in the publication below. Further work is being done in the Saskatchewan Research Council and University laboratories to improve the economic desirability of the process.

Work this year has been concerned with improving the experimental equipment and with study of theoretical aspects which may enable us to reduce process costs considerably.

Mr. Louis Ho assisted in the work for a time during the year.

Publication

Puttagunta, V. R., DeCoursey, W. J., and Bakhshi, N. N. "Reduction of sodium sulphate with hydrogen in a fluidized bed reactor", Can. J. Chem. Eng., 48, 73-79 (1970).

3. Chemical Analysis of Birch Bark *(Betula Papyrifera)*

under the direction of
Professors J. M. Pepper and P. J. Smith

It has long been recognized that local birch bark is capable of resisting microbial decay for long periods of time. This project is concerned with the isolation and identification of the chemical in the bark which are believed to be responsible for the high degree of resistance to microbial attack. Such compounds if identified may be useful for commercial utilization as a preventer of wood rot.

Birch bark, dried and ground, was extracted with petroleum ether followed by diethylether. From these extracts, betulin, approximately 35 per cent by weight of the dried bark, was isolated in pure form and identified using various spectroscopic techniques and elemental analyses. It is of interest to note that birch bark contains a far larger amount of betulin than any other type of tree bark.

Under the experimental conditions used in the preliminary studies it was found that betulin strongly inhibits the growth of several fungi. As well, it was observed that the inhibitory action of betulin is concentration dependent. Several other compounds such as lupeol and betulinic acid, which are related to betulin, were isolated in minor amounts and identified. These preliminary results are encouraging. Further studies are underway to test the compounds other than betulin and to enlarge the biological testing to involve other forms of microbial growth.

Mr. N. Johnson, a summer research assistant, was associated with this project and Mr. G. Dyson, a graduate student, is proceeding with the investigation.

4. Photochemical Degradation of Pesticides and Herbicides

under the direction of
Professor R. G. Sutherland

Further volatility studies on DDT, Dieldrin, Amine salts and esters of 2,4-D, have shown that the surface/mass ratio exposed to the air is at least as important as the vapour pressure in determining the rates of volatilization which obey first order kinetics. It is important to note that this means that a relatively involatile compound such as the octyl ester of 2,4-D can volatilize as rapidly as the volatile methyl ester under appropriate surface/mass ratio conditions.

The rates of penetration of commercial formulations of dodecyl and tetradecylamine salts of 2,4-D into leaves have been measured using both a diesel oil carrier and a conventional aqueous carrier. The long chain amine salts are *ca* 95% absorbed in one hour using the diesel carrier. This can be compared with *ca* 85% absorption in 48 hours using a water carrier. The importance of the chain length of the amine can be demonstrated by the fact that the dimethylamine salt was absorbed much more slowly. This study suggests that the use of a diesel oil carrier for herbicidal dispersal should be investigated further.

The above investigations allow us to estimate the effective exposure times of herbicides to sunlight, and establish the probable importance of photochemical degradation.

2,4-D is converted to the corresponding ester when it is photolysed in alcohols. The rate of the reaction increases with increasing chain length. Removal of one and two chlorine atoms was also observed. Photolysis of esters in alcohols leads to transesterification while photolysis in benzene results in dehalogenation.

Laboratory studies on photochemical degradation have been paralleled by air sampling to detect 2,4-D in the atmosphere, and, hopefully, also its degradation products. Air samples have been collected and analysed in collaboration with Dr. J. Maybank (S.R.C.) and a field study carried out with Mr. K. S. McKinley and Dr. R. Ford of Canada Agriculture. Results suggest that vapour drift is more important than droplet drift.

Several manuscripts are in preparation. Mr. S. S. Que Hee is the graduate student involved and Miss J. Horner and Mr. K. L. Choi worked as summer students.

Publication

S. S. Que Hee and R. G. Sutherland, The Penetration of Amine Salt Formulations of 2,4-D in Sunflowers, Weed Science, in press.

DEPARTMENT OF CIVIL ENGINEERING

1. Study of Foundation Conditions in Downtown Area of Saskatoon

Under the direction of
Professor W. G. Watt

The soils beneath the portion of Saskatoon bounded by the river, Twenty-fifth Street and Avenue B were studied to determine their bearing characteristics. Two glacial tills lie beneath a thin veneer of erratic deposits of clay, sands and silts. These tills are generally dense, relatively incompressible and are the foundation support of most of the buildings of downtown Saskatoon.

With the aid of Dr. E. A. Christiansen of the Saskatchewan Research Council, the geology of this built-up area was mapped to determine the depth to the Floral till, the interface of the Floral and Sutherland tills, and the till-bedrock contact.

Soil samples from testholes were used to establish distinguishing soil characteristics of each till sheet. It is hoped that sufficient differences will exist between the soil parameters of the two till sheets to be able to use the drill logs of previous investigations in the mapping. Piezometers have been set in each drill hole to record the water level.

The mapping will be of direct benefit to potential developers of property in the downtown area. Each owner will have the benefit of a knowledge of the soil conditions beyond the boundaries of his urban lot. Although soils investigations must still be made at each potential building site to define local irregularities, the foundation designer will have the soils information from this study as supplementary material. There is also the possibility that a continual record will be kept of the fluctuations of the water table in the area.

The Province as a whole would benefit if a statistical study of the abundant soils data established differences of engineering significance between these two till groups which occur throughout the southern half of Saskatchewan.

The study team acknowledges assistance from P.F.R.A., S.R.C., B. B. Torchinsky and Associates, and the City of Saskatoon.

DEPARTMENT OF ELECTRICAL ENGINEERING

1. Helium-4 Mass Spectrometry for Uranium Exploration
under the direction of
Professor G. R. Goldak

The purpose of this project is to investigate the use of He-4 Mass Spectrometry as a means of detecting overburden-covered uranium deposits and to construct and test the apparatus required for field procedures. If successful, this method would be extremely valuable in uranium exploration all over the world; in Saskatchewan it might well result in the discovery of new mines in the Uranium City, Wollaston Lake, and Cluff Lake areas. A pilot model helium detection system was designed in 1969 and 1970 and built and laboratory tested in the winter of 1971. During the following summer a good deal of field testing was done, with the collaboration of Mokta Canada Ltée, on their uranium deposits at Cluff Lake. As a result of this field experience instrument modifications were made during the winter of 1971-1972 and further testing was done at Cluff Lake in May 1972. This revealed an anomaly of twice the background in an area where considerable uranium mineralization has been found. However, the exact distribution of uranium is not known at the anomaly site, and so a final interpretation is not possible as yet. Finding suitable test areas has proved to be unexpectedly difficult. In most areas where a uranium deposit is known to exist, a great deal of surface contamination has resulted from the previous exploration.

Further slight modifications to the helium system are now in progress and a sequence of tests for late in 1972 and also for the spring and summer of 1973 is planned.

A paper on this work was presented at the Saskatoon meeting of the Canadian Institute of Mining and Metallurgy in October 1972.

DEPARTMENT OF GEOLOGICAL SCIENCES

1. Field Studies of Microseismic Energy Emission

under the direction of
Professor M. S. King

The occurrence of clay seams in the evaporite formation adjacent to the ore in several Saskatchewan potash mines often presents problems in strata control. These clay seams in some cases are responsible for local failure of the mine roof. A method for predicting such potentially dangerous roof falls is to monitor the microseismic energy released by the rock in areas where strata control problems exist.

A laboratory study in the Department of Geological Sciences of the emission of microseismic energy by samples of potash has shown that a considerable amount of energy is released during the period immediately prior to failure. The object of the research supported under this project is to relate the results of the laboratory study to the prediction of roof failure underground. Results of the research program are expected to assist in determining the optimum safe system of mining potash in areas where roof falls are prevalent.

Equipment necessary to monitor the emission of microseismic energy underground has been designed and constructed at the University of Saskatchewan. It was installed late in 1971 in a local potash mine in an area where a roof fall was expected eventually to occur. A graduate student, Mr. A. Leuschen, has been engaged in recording the energy emission and interpreting the results as a M.Sc. thesis topic during 1972. The system has performed to specifications and there are indications that the number of microseismic events and their intensity increased over the period preceding failure of the roof in September 1972.

2. Stratigraphic Studies in Cretaceous Rocks

under the direction of
Professor W. G. E. Caldwell

Rocks of the Cretaceous System form the bedrock surface throughout southern Saskatchewan and, within the Province, have a greater areal extent than those of any other system in the geological column. Economically, the Cretaceous rocks are important in terms of groundwater, and potentially important as sources of natural gas and industrial minerals. The stratigraphy of these rocks is being studied in detail so that the nature, quantity, and distribution of their natural resources can be assessed and so that the history and geography of Cretaceous times in Saskatchewan can be better understood.

Four lines of stratigraphic investigation, each involving a graduate student, are being pursued at this time.

Mr. M. G. Lomenda has completed a field study of the sand members of the Bearpaw Formation — all of them potential aquifers — in the Cypress Hills and at present is preparing an account of his work as an M.Sc. thesis and for publication. His study has made clear that, rather than there being three sand wedges as was hitherto believed, there are in fact five sand bodies, some of which are lenses. They have a variable development and distribution within the Cypress Hills and environs, and all but one of them are younger than the similar water-bearing sands of the same formation found around Lake Diefenbaker and through the Swift Current uplands.

Mr. D. L. Barlow this year has begun a regional study of sands in the Bearpaw Formation throughout southwestern Saskatchewan. He plans to set in regional context the sands described by Caldwell from the South Saskatchewan River valley (see Geology Division, Rept. 8, 1968), by Rask from the Frenchman River valley (see Annual Rept. for 1969), and by Lomenda from the Cypress Hills. His work will involve the preparation of isopach and structure-contour maps, an analysis of the geometry of the sand bodies, and relating the sands to areas of salt collapse.

Mr. D. H. McNeil has expanded his study of the formations, described originally from the Manitoba escarpment, that underlie the eastern plains of Saskatchewan, and he proposes to present his findings as a Ph.D. thesis in 1974. In the meantime, he will prepare a detailed account of the Ashville Formation, which straddles the important Lower-Upper Cretaceous boundary. This formation contains some persistent sandstones and several thick bentonite seams which yet may be shown to be of economic significance.

Mr. C. E. Wright has completed his investigation of the Upper Cretaceous rocks exposed throughout the length of the Qu'Appelle River valley and encountered in borings (some of them S.R.C. Geology Division testholes) in and near the valley. He has been able to relate the sequence on a time-stratigraphic basis to that established in the South Saskatchewan River valley. From the point of view of reconstructing palaeogeography, he has made an important contribution in being able to date precisely the onset of the final marine invasion to affect not only Saskatchewan but also adjacent portions of the Canadian Interior Plains.

In addition to these studies, an investigation of the foraminiferal faunas of Saskatchewan, leading to a micro-faunal zonal scheme applicable to the entire Cretaceous System throughout the Province, is being continued.

The importance of the Cretaceous System in Saskatchewan and adjacent areas has been recognized by the Geological Association of Canada, which will sponsor an international "Colloquium on the Cretaceous System in the Western Interior of North America" at its annual

meeting to be held in Saskatoon in May, 1973. All members of the Cretaceous research group are involved in organizing the colloquium and many of them also will be presenting papers.

Publication

McLean, J. R., 1971, Stratigraphy of the Upper Cretaceous Judith River Formation in the Canadian Great Plains: Sask. Research Council, Geology Division, Rept. 11, xi + 96 pp., 44 text-figs., 7 pls., 16 tabs.

3. Investigation of the Genetic Aspects of the Flin Flon Ore Body
under the direction of
Professor D. M. Mossman

One of the main objectives of the project is to study systematically the extent to which the Flin Flon base metal deposits may have been affected by metamorphism. An integral part of this study is to up-date information on geological, mineralogical, textural and chemical characteristics of the ores and host rock.

Insofar as no systematic work has been done on the possible metamorphism of the Flin Flon deposits (Byers, 1969)[1] this work is relevant to the exploitation of and exploration for similar ore deposits within Saskatchewan.

The project's objective has been facilitated by a large number of carefully documented samples generously provided by the Hudson Bay Mining and Smelting Company, Flin Flon, and by information on metal ratios throughout the mined-out areas. These data together with analyses of ore and the host rocks are essential to the study in progress. Mr. Ja Hak Koo, a senior student in the Department of Geological Sciences, has now completed the task of data collection and has commenced to incorporate the results in the form of a thesis to be submitted in 1973 for the degree of Ph.D. Tentative conclusions are that the distribution of metals within the Flin Flon deposit is to a considerable extent dependent on degree and kind of metamorphic history and that this distribution is mirrored by characteristic mineralogical and textural criteria.

4. Sedimentary Strata of the Prairies
under the direction of
Professor W. O. Kupsch

Geologists working in Saskatchewan, not only in the southern or "sedimentary" part of the Province with which this project is principally concerned but also with the northern or "Precambrian" part, have for almost 150 years put their findings on paper in reports or on maps. All too often though, those who are working on geological problems today are insufficiently aware of the work by their predecessors. To help these geologists and anyone else interested in the development of the earth sciences in Saskatchewan an annotated bibliography on the geology of the Province has been prepared, kept current, and printed for several years now by the Department of Mineral Resources, Regina.

This year the grant received from the Saskatchewan Research Council made it possible to automate, at least in part, the procedures used in compiling this bibliography. Steps towards computerization had to be taken now that the volume of work produced by the scientists has increased substantially over that of even the recent past. The subject index, a vital component of the bibliography, has been entered on computer cards which will make expansion and sorting of future issues much easier than was possible with the manual operations of the past.

The bibliography project this year was sponsored jointly by the Provincial Government through the Saskatchewan Research Council and the Department of Mineral Resources and by the Federal Government through the Local Initiatives Program of the Department of Manpower.

5. The Proterozoic/Archean Contact in the Vicinity of the Hanson Lake Road, Saskatchewan
under the direction of
Professor M. R. Stauffer

Recent geological work and radiometric dating of rocks between Flin Flon, Manitoba, and Hanson Lake, Saskatchewan, indicates that the rocks near Flin Flon may be of Aphebian age (1800 m.y.), rather than Archean (2400 m.y.) as previously thought, and that there may be an important structural contact between Archean and Aphebian rocks between Flin Flon and Hanson Lake. Since many of the ore deposits that occur within the Canadian Shield are located along or near contacts between rocks of vastly different ages, it is of considerable possible economic (as well as scientific) importance that this contact be investigated, first to determine its existence, and secondly to delineate its location.

The present project involves Rb/Sr, Pb/Pb and K/Ar dating of intrusive and volcanic rocks south and west of Flin Flon, in order to determine their age(s) and thermal histories. To date, one paper has been published, based on the preliminary data collected from this and other studies in the area. By next year, dating of the rocks further west, in the Hanson Lake area, will have been carried out to complete the first phase of the project. One student, Mr. Rod MacQuarrie, is working on this project at present, and should be finished his M.Sc. thesis by fall 1973.

Publication

Mukherjee, A., Stauffer, M. R., and Baadsgaard, H., 1971, The Hudsonian Orogeny near Flin Flon, Manitoba: a tentative interpretation of Rb/Sr and K/Ar ages: Can. Jour. Earth Sci., v. 8, p. 939-946.

[1]Byers, A. R., 1969, The Coronation Mines Project *in* Symposium on the geology of the Coronation Mine, Saskatchewan: Geol. Survey Can. Pap. 68-5, p. 201-212.

COLLEGE OF HOME ECONOMICS

1. Pollution of Soil, Water and Food by Pesticide Residues in Saskatchewan

under the direction of
Professor A. K. Sumner

Research was continued on methods for reducing the uptake of organochlorine pesticides by crops grown in contaminated soil and for decreasing the residue level in the soil as well as on an evaluation of suitable vegetable crops to grow on heavily contaminated soils. Studies were concluded on procedures for analyzing Dyfonate (a new organophosphorous pesticide) residues in crops and soil and an investigation was commenced on the photodecomposition of Dyfonate. Research was completed on the metabolism of inorganic and phenylmercury compounds by Rainbow trout and work was continued on the development of a method to remove methylmercury from processed fish. These studies were carried out in collaboration with Dr. J. G. Saha, Canada Agriculture Research Station, Saskatoon. University and other personnel associated with this research were Dr. Maitreyi Saha, Mrs. Diane Simpson, Miss Brenda Smith and Mr. Lorne Harman.

Organochlorine Pesticide Residues in Soil

Experiments were carried out in the greenhouse to determine the effects of incorporating different types of organic matter on the uptake of dieldrin (an organochlorine insecticide) by wheat plants. Urea at a concentration of 100 ppm (200 pounds per acre) was most effective and reduced uptake by 51%. Reductions in dieldrin uptake of 30 to 50% were achieved with 0.1% soybean meal, 1% lignin and 100 ppm humic acid. A 5% concentration of peat was less effective in reducing the uptake of dieldrin. Field trials should be carried out to confirm the effectiveness of urea.

Trials are being carried out at Broderick and Outlook to determine the most suitable crops to grow on Saskatchewan vegetable farm soils which are contaminated with chlordane, an organochlorine pesticide and Dyfonate, an organophosphorous pesticide. The crops being investigated are potatoes, carrots, peas, rapeseed, alfalfa and barley. The crops have been harvested and will be analyzed for pesticide residues.

Analysis for Dyfonate

Work on the development of methods for analysis of Dyfonate residues in plants and soils was completed. The effect of various solvents in removing Dyfonate-ring-^{14}C from soil was evaluated and three methods were compared for determining root-absorbed ^{14}C labeled Dyfonate. Two research papers on this work have been accepted for publication.

Metabolism and Photodecomposition of Dyfonate

Due to unforseen difficulties in the synthesis of ^{14}C labeled Dyfonate, research on the metabolism of Dyfonate by plants was abandoned. However, photodecomposition of Dyfonate was studied. Two of the major decomposition products were identified by infrared and mass spectroscopy. These are thiophenol and diphenydisulfide. Further work on the identification of other photodecomposition products is in progress.

Conversion of Mercury Compounds by Rainbow Trout

Research on the conversion of various mercury compounds to highly toxic methylmercury was completed. The results showed that Rainbow trout were incapable of converting mercuric nitrate, mercuric chloride or phenylmercuric acetate into methylmercury. A research paper will be prepared and submitted on this project.

Publications

Saha, J. G. and A. K. Sumner. 1971. Organochlorine Insecticides in Soil from Vegetable Farms in Saskatchewan. Pesticides Monit. J. 5 (1) 29.

Saha, Maitreyi and A. K. Sumner. Comparison of Three Methods for Determining Root-absorbed Dyfonate (0-ethyl S-phenyl-^{14}C (U)-ethylphosphonadithionate) in Wheat Plants. J. Assoc. Offic. Anal. Chem. In Press.

Sumner, A. K. and J. G. Saha. 1971. Methylmercury Concentrations in Muscle Tissues of Fish from the Saskatchewan River. Environmental Letters 2 (3), 1967.

Sumner, A. K., J. G. Saha and Y. W. Lee. 1972. Mercury Residues in Fish from Saskatchewan Waters With and Without Known Sources of Pollution. Pesticides Monit. J. 6 (2) 122.

Sumner, A. K. and Maitreyi Saha. Extraction of Residues of Dyfonate-ring-^{14}C from Soil. International Journal of Environmental Analytical Chemistry. In Press.

DEPARTMENT OF HORTICULTURE SCIENCE

1. Irrigation Studies with Vegetable Crops

under the direction of
Professor D. H. Dabbs

The objectives of this continuing study have been stated in previous annual reports. In general, the purpose is to develop more precise guidelines for growers of irrigated vegetable crops in Saskatchewan.

For the second year both the Darkskin Perfection variety of freezer peas and the Contender variety of snap beans were grown on an Asquith fine sandy loam at Saskatoon in 1972. For both crops irrigation water was supplied in order to maintain soil moisture levels at a minimum of 50 per cent of field capacity. All possible combinations of 0, 25, 50 and 75 pounds per acre of nitrogen (N), as well as 0, 50 and 100 pounds of phosphorus ($P_2 0_5$) were banded to the rows of both crops at planting time. Soil sampling for nutrient analysis was conducted prior to fertilizer application.

From the statistical analyses completed to date, it seems apparent that the inherent levels of nitrogen (77 lbs. of N/A to the 24" depth) and of phosphorus (39 lbs. of $P_2 0_5$ /A to the 6" depth) were sufficient for a maximum crop of peas. Single harvest yields of high quality shelled peas from these plots and from a demonstration field of 0.58 acres at Outlook again exceeded the average yields obtained in most other pea-producing areas.

Two harvests were made on snap beans in 1972 and exceptionally high yields were obtained. In spite of the relatively high soil nutrient levels at planting time there were several plant responses to applied fertilizer. There were significant differences in plant height and plant spread by the end of July with those plants receiving additional nitrogen, and particularly those receiving additional nitrogen as well as phosphorus, showing significantly more growth. These same general responses carried through to the marketable yield of pods. The highest yield was obtained from the addition of at least 25 lbs. of N and 25 lbs. of $P_2 0_5$ per acre.

The above studies were conducted in close cooperation with Mr. L. G. Sonmor, Irrigation Specialist, Research Branch, Canada Department of Agriculture, Saskatoon.

The final results of the special rutabaga trial at Outlook in 1971 indicated boron soil and foliar levels were very close to the deficiency level, as recognized by most research workers elsewhere. There would thus appear to be a definite possibility of a boron deficiency for certain crops in some of the light textured irrigated soils in this particular area of Saskatchewan either at the present time or in the near future.

As a consequence of the evidence of 1970 and 1971 a more elaborate rutabaga trial was conducted near Outlook in 1972 in close association with the Department of Soil Science, University of Saskatchewan and with Mr. R. W. O'Donnell of the Saskatchewan Research Council, University Campus, Saskatoon. A split plot design was used with three levels of Leonardite (0, 1000 and 2000 lbs/A) superimposed on five fertility treatments (check; 70 lbs. N and 35 lbs. $P_2 0_5$ /A; 70 lbs. N and 35 lbs. $P_2 0_5$ plus 4 lbs. boron/A as soil applied; 70 lbs. N and 35 lbs. $P_2 0_5$ plus 8 lbs. boron/A as soil applied; and 70 lbs. N and 35 lbs. $P_2 0_5$ plus two foliar applications of 0.5 lbs. boron each/A). At time of writing only the actual yield data is available, as the soil and plant analyses have not been completed.

The inherent soil fertility level of 67 lbs. of N (to 24" depth) and 31 lbs. of $P_2 0_5$ (to the 6" depth) was apparently sufficient to produce a maximum potential crop of rutabagas when soil moisture levels were not allowed to drop below 50 per cent of yield capacity, as an average yield of 24 tons per acre was obtained. This was an excellent yield as the U.S.D.A. considers 10 tons per acre to be a good yield. No visual symptoms of boron deficiency were detected in 1972.

2. Remote Sensing of Moisture Stress, Weed Competition and Salt Accumulation

under the direction of
Professor S. H. Nelson

Remote sensing as a 'diagnostic tool' has received considerable attention in many disciplines. Early work in agriculture has centered around disease and the 'false color', particularly color infrared, and signatures of this type of stress. Preliminary investigations however would suggest that remote sensing techniques using aerial photography could also be used in crop and weed identification, as well as for other forms of stress relating to moisture regimes in the plant originating from lack of irrigation, competition or salt accumulation.

The work on this grant was initiated in 1972 on potatoes in the South Saskatchewan Irrigation Project. Studies were conducted on commercial fields of potatoes, or small plots of various crops on light sandy loam and heavy clay loam at Saskatoon.

The project was supplemented by participating in the Provincial Employment Program and some 300 acres were critically ground-truthed by three students, the vegetation, and other features being plotted. On the day of the flight additional information was collected including foliage and soil samples for moisture determination on six properties. Samples were taken across the field of right angles to the wheel-move systems.

On August 11, 1972, two flights were made. A rented Piper Twin Apache aircraft modified with floor port to hold a four-hasselblad 70 mm camera mount was used by University personnel. The film-filter combinations

were as follows:

(1) Ekatchrome ER8442 film without filter.
(2) Ektachrome ER8442 film with minus blue filter.
(3) Aerochrome Infrared 2443 film with minus blue filter, and
(4) Aerochrome Infrared 2443 film with a deep red filter.

This flight was made at an altitude of 4800 feet AMSL. The other flight was made by the Canada Centre for Remote Sensing at an altitude of 17,000 feet AMSL and produced the following combinations:

(1) Black and white Infrared 2424 film,
(2) Black and white Infrared 2405 film with green filter,
(3) Black and white Infrared 2402 film with red filter,
(4) Aerochrome Infrared 2443 film with minus blue filter,
(5) Aerocolor 2442 film.

Unfortunately, the other planned flight by the Canada Centre for Remote Sensing at an altitude of 2000 feet AMSL could not be executed on this date and when the Dakota aircraft was available the season had past.

The imagery from the University Flight was developed by the National Photographic Laboratory in Ottawa and the 70 mm transparencies, some 450 with sufficient overlap for stereo viewing, are now being mounted. A scanning of the imagery reveals that the photographic resolution is excellent. Sample proofs and flight lines from the Canada Centre for Remote Sensing has just been received and area identification of exposures is now in progress for selection of ground-truthing sites so that enlargements can be ordered.

With the imagery just being received, there has been no opportunity to study the transparencies extensively in close association with ground-truthing data. These will be carried out during the winter using low magnification stereo viewing for scanning and a Zeiss/Jena Interpretoscope for greater detail studies. It is also apparent that a stage microscope can be used if individual plants need to be studied. This will overcome the problem of the missing low-level flight. Exploratory work has also been carried out with line densitometer readings across the transparency. To date, however, the opposing trends of plant and bare ground reflectance in pure stands have given confusing results as far as water regimes are concerned. Further work with aperture size and filters is planned during the winter.

DIVISION OF NATURAL SCIENCES AND MATHEMATICS — Regina Campus

1. Preparation of Pure Inorganic Salts

under the direction of
Professor K. E. Johnson

The objective of this research program is to investigate the applicability of the zone melting technique to the purification of inorganic salts (e.g., potash and sodium sulphate) which occur in the Province. These salts have potential as molten electrolytes for fuel cells and the electro-winning of metals if a sufficient degree of purity can be achieved. Also these materials could serve as heat storage media. This latter application would require pure materials to avoid excessive corrosion. Development of this high temperature technology could lead to the growth in the Province of light chemical plants for producing these pure salts for the associated industries.

Reagent grade potassium chloride has been cast into ingots and zone refined by passing the ingot through a radio frequency heating coil. The potassium chloride was doped first with calcium chloride and later with magnesium chloride. The rate of travel of the doped ingot through the hot zone can be controlled over a wide range. The doped ingots were analyzed after one pass through the hot zone by flame emission spectroscopy. Calcium ion shows no preference for the liquid phase with respect to the solid phase (distribution coefficient approaching unity) and is not separated by the zone refining method. However, barium ion does show a preference for the liquid phase and can be removed from the potassium chloride matrix. The distribution coefficient for barium ion in potassium chloride is currently being measured. Background data on the removal of heavy metals and alkaline earth metals from potassium chloride is essentially complete and the purification of local potash by zone refining is in progress.

The assistance of Drs. S. J. Sime and E. O. Shreman, Mrs. J. Wallace and Mr. M. Korchinski with this project is gratefully acknowledged.

2. Isolation on Structure Determination of Diallate Herbicide Isomers

under the direction of
Professor F. H. A. Rummens

One phase of our work on the herbicide Diallate (Avadex) was rounded off by submitting a paper to the Journal of Agriculture and Food Chemistry; F. H. A. Rummens "Separation and Structural Assignment of the Cis and Trans Isomers of S-2,3-Dichloroallyl N,n-Diisopropylthiolcarbamate (Diallate)".

The second stage of our work on Diallate — the physical, chemical and biological properties of the two separate isomers — is still in progress. Completed is the part on the herbicidal activity against wild oats. Other properties like adsorptivity on soils, chemical and biological degradation remain to be done.

A start was made on a project to develop new techniques to detect herbicides of the chlorophenoxy acids family at lower concentrations. The 2,4-D can be easily detected at 10 ppb levels using electron-capture detection in GLC, but such related pesticides as MCPA and MCPB have a detection limit of about 500 ppb (0.5 ppm). To improve this situation, the acids are esterfied with halogen-containing alcohols, with the intent that the extra halogens will boost the electron-capturing efficiency of the molecules. Work done on one such esterification process, with mono-cloroethanol, has been completed. Two other processes involving CCl_3-CH_2 0H and pentafluoro benzylalcohol as esterifying agents still have to be investigated.

We would like to acknowledge the assistance of Mrs. A. de Meyer (Technician), of Mr. R. D. Dillen, who obtained his B.Sc., Honours, on a thesis entitled "Detection Limits of Herbicide Derivatives Using Electron Capture Gas Chromatography" and of Mr. P. Murtagh who was also, in part, supported by a Province of Saskatchewan Summer Employment Grant.

3. Method for Investigating and Utilizing Lakewater Algae

under the direction of
Professor D. R. Cullimore

The objective of this project has been to examine methods of harvesting algae with a view to its use as an animal food.

The value of such a study is that it would remove algae from lake systems and at the same time provide an economically viable product. Studies conducted during the summer and fall of 1971 were concentrated on evaluating the algal biomass of algae in the different lake systems (report, Cullimore and Johnson 1971). Factors affecting the size of this biomass have also been extensively studied by bioassay and *in vivo* observations. These revealed that the algal growth is controlled, to a considerable extent, by the amount of nitrogen available in the water system (Cullimore, 1972; Cullimore and McCann, 1972; further studies to be reported). A literature review has been conducted on the various methods by which algae can be harvested and no existing method would appear to be economically viable at this time. Methods for removing algae from water bodies by precipitation using alum, lime and flyash have been subjected to initial study.

Gratitude is expressed to Mrs. P. Kemp, Miss D. Gebert, and Mrs. M. Kohout for their aid in this project.

Publications

Cullimore, D. R. and Johnson, K. E., "Report on Qualitative Study of the Qu'Appelle Lakes", Qu'Appelle Basin Study, Item 410, December 1971.

Cullimore, D. R. and McCann, A. E., "Initial Studies on a Method of Algal Assay for Nutrient Parameters in Water", J. Fish. Res. Bd. Canada 29, 195-198.

Cullimore, D. R., "A Biological and Chemical Survey of the Qu'Appelle Lakes", Blue Jay (In Press).

COLLEGE OF PHARMACY

1. Culture of Medicinal Plants

under the direction of
Professors N. W. Hamon, D. A. Zuck, and E. T. Hughes

The study on the possibility of introducing peppermint (Mentha piperita) as a secondary cash crop was continued during 1972.

Previous studies established soil requirements and water requirements (see 23rd Annual Report, 1969, p. 92; and 24th Annual Report, 1970, p. 85).

The main problem in the Saskatoon area is still winter kill. Snow fencing was erected to trap the 1971 snow as a winter cover. Survival was once again about 50 per cent.

In an attempt to increase the oil yield to compensate for winter kill of plants, the nitrogen fertilizer was increased from 120 lb. acre^{-1} to 180 lb. acre^{-1}. This increased the quantity of hay markedly but the oil yield was reduced to 27.5 lb. acre^{-1}. This low oil yield can only be attributed to the very cool and damp growing season of 1972.

The hay was harvested at the 0-5 bloom stage since oil composition and quality is based on time of harvest. The evaluation of the oil quality of the 1972 crop is still in process (see Publication).

A field trip to the state of Michigan and Indiana was taken by Drs. Zuck and Hamon to obtain information on how those growers protect plants against winter kill. (Winter kill is no problem in Yakima Valley). Indiana and Michigan land used for peppermint growing is irrigated muckland of rather low density. The fields are heavily irrigated and shallow-plowed prior to freeze-up. In spring, the plants grow through the furrow. This procedure performs a triple function — it prevents frost kill, it keeps the crop thinned out and it helps keep weeds under control. This procedure is under investigation during the winter of 1972-73 to determine its feasibility for our climate.

Arrangements were made to obtain a wilt-resistant strain of Mentha piperita (Todd Mitchum) which was developed in Michigan. We would like to introduce this strain and compare its oil yields and oil quality in this part of the country.

The study on use of herbicide to control weeds, we feel, should continue.

In addition, we would like to do some of this work in the southern part of the Province, probably in cooperation with the Canada Department of Agriculture Research Station in Swift Current where irrigated land is available and the climate is less severe.

Growing dill for its oil was continued in 1972. The yields were fairly impressive and were influenced markedly by time of harvesting. Plants one-half in bud state and one-half in bloom yielded 48 lb. of oil per acre. Plants one-half in bloom and one-half in seed yielded 64 lb. of oil per acre. In both cases plant rows were fifteen inches apart which may or may not be optimum.

It is the feeling of this group that the study should continue.

Publication

N. W. Hamon and D. A. Zuck, Peppermint as a Cash Crop in Saskatchewan, Can. J. Plant Sci. 52, 837-839, Sept. 1972.

DEPARTMENT OF SOIL SCIENCE

1. Evaluation of Soil Contamination in the Vicinity of Potash Refineries

under the direction of
Professor D. A. Rennie

The purpose of this continuing project is to evaluate the effect of the accumulation of air-borne salts from potash refineries on soil productivity. The project is sponsored jointly by the Potash Section of the Saskatchewan Mining Association and the Saskatchewan Research Council. A. K. Ballantyne, E. H. Halstead, and C. G. E. M. van Beek supervised the field and laboratory investigations and the computer assisted data analyses.

Systematic Analysis of Data

A systematic analysis of all the data obtained from the soil sampling program between 1964 and 1971 has been completed. A report entitled "Movement and accumulation of salts around potash refineries in Saskatchewan" will be available for distribution early in 1973.

The study included the following:

1) The preparation of data summaries, on a soil association basis, of all the analytical criteria used to evaluate salt movement and accumulation in soils.

2) The calculation of cation exchange coefficients for each of the sample depths on a soil association basis.

3) Estimation of the net upward or downward movement of water in the soil and its relation to movement of salts. This was made possible by climatological data supplied by the Saskatchewan Research Council.

4) Calculation of the amount of KCl entering the soils in the vicinity of refineries through a systematic analysis of chlorine ion concentration and movement. In general, the data suggest uneven distribution of the dustfall in the soil and detectable amounts ranging between 0 and 25 lb. of KCl per acre per year when expressed on a mine-area basis.

5) Simulation computer programs were used to predict the possible future accumulation of chlorides in the soil using past climatological data and current permissible dustfall levels.

Soil Sampling Program

The soil benchmark sites located within a three-mile radius of each of the nine refineries participating in this program were sampled in the fall of 1972. The restriction of the sampling program to the area within a three-mile radius of the refineries was in accord with a major recommendation arising out of the systematic analysis of the past data. It has subsequently been decided temporarily to discontinue the field sampling program since analysis of the data has clearly shown that significant accumulation of KCl salts is not likely to occur provided dustfall emission does not exceed that characteristic of the past two years.

The two field plots where salt dust was applied at rates ranging from 0.5 to 15 tons per acre were sampled again in 1972. Due to different characteristics of chloride movement in the soils at these two sites the sampling and analysis program will be continued.

Crop Monitoring Program

This portion of the study is designed to correlate atmospheric chloride levels with the chloride content of plant tissue. The research carried out in 1971 indicated that the chloride content of annual crops was usually higher, although not critical, in samples taken near refineries than in those taken further away. This pattern of chloride levels in vegetation was found to be related to dustfall chloride levels monitored by the Department of the Environment. In 1972 the project was continued, however, soil samples were also taken from the plant sampling sites in an attempt to further define the contribution of soil and atmospheric chlorides to the levels found in plants.

Remote Sensing Program

In 1971 a project was initiated to assess the usefulness of multiband photography as an aid in delineating the effects of air-borne salts on soils and crops. Imagery was obtained in early August of 1971 from the air-borne program of the Canada Centre for Remote Sensing. While plant tissue analysis suggested greater exposure of vegetation to chloride near potash refineries, any effects were not evident on the imagery obtained. The project was continued in 1972 with two flights being made over the portion of the potash belt located in the Saskatoon area. An assessment of this imagery has not as yet been carried out.

Publications

Buswell, J. C., 1972. Chloride levels of plants sampled near potash refineries. B.S.A. Thesis, Dept. of Soil Sci., Univ. of Saskatchewan, Saskatoon.

Halstead, E. H. and D. A. Rennie, 1972. Experimental program on remote sensing for crop identification and pollution detection. Proc. Can. Remote Sensing Symposium, Ottawa (In Press).

van Beek, C. G. E. M., E. H. Halstead, D. A. Rennie, and A. K. Ballantyne, 1972. Movement and accumulation of salts in soils around potash refineries in Saskatchewan (In Press).

STAFF OF THE SASKATCHEWAN RESEARCH COUNCIL

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FINANCIAL STATEMENT

GOVERNMENT OF THE PROVINCE OF SASKATCHEWAN

THE SASKATCHEWAN RESEARCH COUNCIL

AUDITOR'S REPORT

For the Fiscal Year Ended March 31, 1972

Pursuant to Section 20 of The Research Council Act, being Chapter 406, Revised Statutes of Saskatchewan, 1965, I have examined the balance sheet of The Saskatchewan Research Council as at March 31, 1972, and the statement of equity in fixed assets and the statements of operations and operating surplus for the year then ended. My examination included a general review of the accounting procedures and such tests of accounting records and other supporting evidence as I considered necessary in the circumstances.

In my opinion these financial statements present fairly the financial position of the Council as at March 31, 1972 and the results of its operations for the year then ended, in accordance with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

W. G. Lutz, (signed)

Regina, Saskatchewan
September 20, 1972.

W. G. Lutz, C. A.
Provincial Auditor

Statement 1

THE SASKATCHEWAN RESEARCH COUNCIL

BALANCE SHEET

As at March 31, 1972
With comparative figures at March 31, 1971

ASSETS

	1972	1971
Current:		
Cash	$ 4.873	$ 495
Guaranteed savings deposit — 4-1/2%	112.358	38.189
Accounts receivable	189.181	172.409
Prepaid expenses and deposits	11.663	9.771
Total current assets	$ 318.075	$ 220.864
Investments — Cost		
Province of Saskatchewan Savings Bonds	$ 50.000	$ 60.000
Deposit receipt — 7%	10.000	
	$ 60.000	$ 60.000
Fixed — Cost (Note 1)		
Laboratory equipment	$ 535.443	$ 573.322
Automotive equipment	84.877	81.223
Building	81.000	81.000
Furniture and fixtures	66.118	55.131
Shop equipment	46.168	50.962
Land	10.000	10.000
	$ 823.606	$ 851.638
	$1.201.681	$1.132.502

LIABILITIES AND EQUITY

	1972	1971
Current:		
Bank overdraft		$ 24.523
Accounts payable	$ 86.016	40.619
Employee deductions payable	10.432	2.094
Total current liabilities	$ 96.448	$ 67.236
Equity:		
Equity in fixed assets (Statement 2)	$ 823.606	$ 851.638
Operating surplus (Statement 3)	281.627	213.628
	$1.105.233	$1.065.266
	$1.201.681	$1.132.502

Statement 2

THE SASKATCHEWAN RESEARCH COUNCIL
STATEMENT OF EQUITY IN FIXED ASSETS

For the Year Ended March 31, 1972
With comparative figures for the year 1971

	1972	1971
Equity in fixed assets, beginning of year as previously reported		$ 901,263
Adjustment of prior years for equipment charged to operating surplus but not recorded in the fixed asset accounts		14,352
Adjustment of prior years for supplies previously credited to equity in fixed assets		(8,991)
As restated	$851,638	$ 906,624
ADD:		
Fixed asset additions		
— research payments (Statement 4)	92,819	110,905
— administrative (Statement 5)	13,960	7,117
	$958,417	$1,024,646
DEDUCT:		
Fixed asset disposals		
— written off (Note 1)	$125,172	$ 158,923
— sold	9,639	14,085
	$134,811	$ 173,008
Equity in fixed assets, end of year	$823,606	$ 851,638

Statement 3

THE SASKATCHEWAN RESEARCH COUNCIL
STATEMENTS OF OPERATIONS AND OPERATING SURPLUS

For the Year Ended March 31, 1972
With comparative figures for the year 1971

	1972	1971
Revenue:		
Cost sharing arrangements and grants		
— Government of Canada	$ 505,469	$ 490,930
— Province of Saskatchewan	1,182,102	1,091,772
— Industry	139,333	16,197
	$1,826,904	$1,598,899
Fees for services	60,324	39,593
Investment income	13,732	16,287
Proceeds on disposal of fixed assets	5,255	4,405
Other income	1,831	2,567
Total Revenue	$1,908,046	$1,661,751
Expenditures:		
Research (Statement 4)	$1,554,214	$1,413,291
Administrative (Statement 5)	285,833	270,321
	$1,840,047	$1,683,612
Surplus (deficit)	$ 67,999	($ 21,861)

OPERATING SURPLUS

Operating surplus, beginning of year		
As previously reported		$ 226,498
Adjustment of prior years for supplies previously credited to equity in fixed assets		8,991
As restated	$ 213,628	$ 235,489
Surplus (deficit) for the year	67,999	(21,861)
Operating surplus, end of year	$ 281,627	$ 213,628

Statement 4

THE SASKATCHEWAN RESEARCH COUNCIL
STATEMENT OF RESEARCH EXPENDITURES

For the Year Ended March 31, 1972
With comparative figures for the year 1971

	Chemistry	Engineering	Geology	Industrial	Physics	1972 Total	1971 Total
Employee benefits	$ 9.585	$ 8.670	$ 8.690	$ 4.399	$ 4.798	$ 36.142	$ 34.182
Fixed asset purchases	28.375	25.069	15.180	1.091	23.104	92.819	110.905
Printing	70	3.896	72.224	6.842	3.738	86.770	83.789
Salaries	163.021	289.619	170.229	92.488	154.212	869.569	812.264
Sundry	4.085	25.465	14.323	4.793	6.177	54.843	39.416
Supplies	13.287	33.571	21.410	14.954	18.918	102.140	97.320
Technical services	3.128	64.870	134.086	1.335	55.065	258.484	177.164
Travel	4.111	6.719	9.074	8.926	6.002	34.832	37.909
Vehicle operation	589	3.905	13.460		661	18.615	20.342
	$226.251	$461.784	$458.676	$134.828	$272.675	$1.554.214	$1.413.291

Statement 5

THE SASKATCHEWAN RESEARCH COUNCIL
STATEMENT OF ADMINISTRATIVE EXPENDITURES

For the Year Ended March 31, 1972
With comparative figures for the year 1971

	1972	1971
Contractual services	$ 14.679	$ 12.322
Employee benefits	6.213	6.842
Fixed asset purchases	13.960	7.117
Grants (Statement 6)	73.135	80.716
Insurance and utilities	18.387	18.614
Postage and communication	4.426	4.636
Printing, publicity and advertising	23.009	13.677
Professional services	1.447	1.583
Repair and maintenance		
— building	9.063	11.434
— equipment	341	655
Salaries		
— director and assistant director, part time	40.540	39.305
— division head	13.010	12.992
— other	53.255	49.778
Stationery and office supplies	6.255	3.918
Sundry	203	225
Travel	3.356	3.930
Vehicle operation	4.554	2.577
	$285.833	$270.321

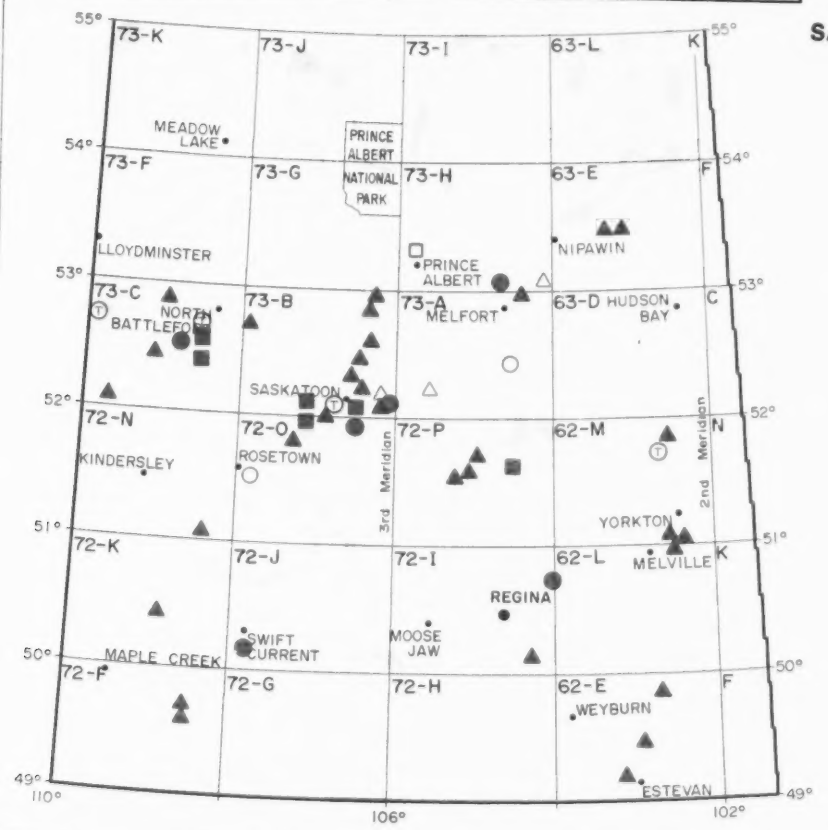
Statement 6

THE SASKATCHEWAN RESEARCH COUNCIL

STATEMENT OF GRANTS FOR RESEARCH PROJECTS

For the Year Ended March 31, 1972

Petrology and Structure of Anhydrite Beds	$ 333
Pea Protein as a Protein Source in Milk	2,795
The Culture of Medicinal Plants	3,625
Sedimentary Strata of the Prairies	883
Helium-4 Mass Spectrometry for Uranium Exploration	1,958
Pollution of Soil, Water, etc. by Pesticide	4,000
Photochemical Degradation of Pesticides etc.	4,000
Hydrogen Reduction of Sodium Sulfate	3,281
Studies of Microseismic Energy Emission	5,000
Genetic Aspects of the Flin Flon Ore Body	3,500
Irrigation and Fertilizer Studies — Vegetable Crops	3,129
Soil Contamination from Potash Refineries	18,600
Research in Fluid-Solids Systems	3,500
Structural Geology of Saskatchewan	1,250
Stratigraphic Studies in Cretaceous Rocks	3,200
Algae Cultured in or upon Saskatchewan Lakes	5,400
Production of Pure Inorganic Salts	2,528
Determination of Diallate Herbicide Isomers	1,600
Purchase of Automotive Equipment for the University of Saskatchewan	4,553
	$73,135



LOCATION OF SASKATCHEWAN RESEARCH COUNCIL FACILITIES

EXPLANATION

- ▲ Observation well
- □ Topoclimatological station
- ○ Pesticide sampling site
- △ Spray freezing site
- ● Slough study
- ⓣ Tritium study
- ■ Watershed